DREDGED MATERIAL RESEARCH PROGRAM

MISCELLANEOUS PAPER D-77-5

REVIEW OF DREDGED MATERIAL DISPOSAL TECHNIQUES TO IDENTIFY WILDLIFE HABITAT DEVELOPMENT FACTORS

by

Dames & Moore
500 Sansome Street
San Francisco, Calif. 94111

December 1977

Final Report

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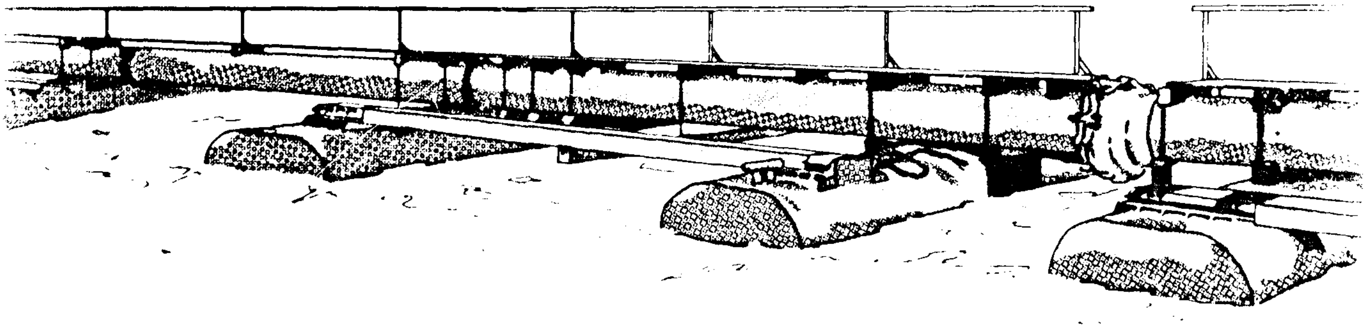

Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

Under Contract No. DACW39-74-C-0033
(DMRP Work Unit No. 5B04)

Monitored by Environmental Effects Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

DEPARTMENT OF THE ARMY
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IN REPLY REFER TO WESYR

31 January 1978

SUBJECT: Transmittal of Miscellaneous Paper D-77-5

TO: All Report Recipients

1. The report transmitted herewith represents the results of Work Unit 5B04, in which dredged material disposal techniques were reviewed to identify wildlife habitat enhancement possibilities. This work unit was conducted as part of Task 4B (Terrestrial Habitat Development) of the Corps of Engineers' Dredged Material Research Program (DMRP). Task 4B is part of the Habitat Development Project (HDP) of the DMRP and is concerned with the development, testing, and evaluation of the environmental, economic, and engineering feasibility of using dredged material as a substrate for terrestrial habitat development.

2. The purpose of this work unit was to examine inland confined dredged material disposal sites in the United States and identify their general vegetation, soil, and wildlife characteristics, and to determine if the disposal techniques used at those sites were compatible with wildlife habitat. Five regions of the country, the Great Lakes, North Atlantic, South Atlantic, Gulf Coast, and Pacific Coast, were examined and the results are presented on a regional basis. Possible habitat enhancement procedures were discussed in detail for one site from each region.

3. Work Unit 5B04 is one of several research efforts designed by the DMRP to determine a wide range of possibilities for terrestrial habitat development using dredged material. Closely related work units are 5B03, 4B01, 4A13, 4B04, 4B05, and all of Task 4F. Work Unit 5B03 describes plant and animal succession patterns on five upland disposal sites in the United States. Work Unit 4B01 categorizes habitat on a variety of disposal sites. Vegetative succession on and management of dredged material islands for avian habitat is the subject of Task 4F and its associated seven work units. Substantial additional information will be forthcoming with the final analysis of the results from upland habitat development at Nott Island, Connecticut (4B04), Bolivar Peninsula, Texas (4A13), and Miller Sands, Oregon (4B05). Together these

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research products will provide the Corps of Engineers with the basis for sound management decisions regarding terrestrial habitat development on dredged material.

JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director

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Disposal areas	Waste disposal sites
Dredged material disposal	Wildlife habitats
Succession	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Habitats of 15 inland confined dredged material disposal sites throughout the United States were studied along with present disposal techniques for dredged material. The purpose was to determine wildlife enhancement alternatives. The objective in identifying alternate dredged material disposal techniques was to enhance the present wildlife habitat of the disposal site, and yet be

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20. ABSTRACT (Continued).

nonconflicting with the present wildlife setting. On the other hand, these alternates were not to unduly conflict with the present maintenance dredging techniques and equipment capabilities.

Following review of the field data, one generalization can be made: the smaller the confined disposal area, the more rapidly ecological succession of the disposal site will occur. Succession depends on the size of the site and frequency and location of the deposition of the dredged material on the site. For example, the large disposal areas are repeatedly used and vegetation succession is arrested in an early state. Larger disposal sites also make colonizers more remote to the majority of the site. If larger areas are partitioned by diking, deposition in one of the smaller plots will not influence succession in adjacent confinements.

Specific enhancement alternatives were developed for 5 of the 15 disposal sites. Environmental and economic costs and benefits of proposed alternate disposal techniques were categorized into short-term and long-term costs. Benefits were compared to the present costs.

PREFACE

This report presents the results of a comprehensive review and examination of disposal area filling techniques and rates to identify nonconflicting wildlife enhancement alternatives. This investigation was conducted as part of the Corps of Engineers Dredged Material Research Program (DMRP), which is sponsored by the Office, Chief of Engineers (DAEN-CWO-M). The DMRP is assigned to the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, under the Environmental Effects Laboratory (EEL).

This is the final report of work performed under Contract No. DACW39-74-C-0033 (DMRP Work Unit No. 5B04) and covers Task I--Survey of Present Dredged Material Disposal Techniques and Wildlife Habitats; Task II--Identification of Alternatives to the Present Disposal Techniques; and Task III--Rationale for Selection of Five Potential Test Sites.

The work described in the report was performed during the time period of October 1973 to May 1974 by Dames & Moore, San Francisco, California. Messrs. Leon Winters and Carl Garbe were the project administrators. The project manager was Mr. Michael Hess, and the technical coordinators were Drs. Frederick Shanholtzer and David Valentine.

Directors of WES during the study and preparation of the report were COL G. H. Hilt, CE, and COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown. Dr. John Harrison was Chief, EEL, and Dr. R. T. Saucier was Special Assistant, EEL. The study was conducted under the general supervision of Dr. C. J. Kirby, Project Manager for Habitat Development Research. Ms. Jean Hunt was Contract Manager.

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	25.4	millimeters
feet	0.3048	meters
miles (U. S. statute)	1.609344	kilometers
acres	4046.856	square meters
square miles	2.589988	square kilometers
cubic yards	0.7645549	cubic meters
pounds (mass)	0.4535924	kilograms
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C = (5/9) (F - 32). To obtain Kelvin readings, use: K = (5/9) (F - 32) + 273.15.

Summary

Habitats of inland confined dredged material disposal sites were studied along with present disposal techniques for dredged material to determine wildlife enhancement alternatives. The objective in identifying alternate dredged material disposal techniques was to enhance the present wildlife habitat of the disposal site, and yet be nonconflicting with the present wildlife setting. On the other hand, these alternates were not to conflict unduly with the present maintenance dredging techniques and equipment capabilities.

The contiguous United States were grouped into five regions:

a. Great Lakes

b. North Atlantic

c. South Atlantic

d. Gulf Coast

e. Pacific Coast.

Initially, 27 sites distributed among 11 Corps District offices throughout these regions were reviewed. Fifteen of these sites, three from each of the five regions, were selected for detailed field studies. The field studies, conducted by five experienced biologist and soils engineer teams during November and December 1973, established the type of habitat by vegetation transect methods. The dredged material characteristics (physical) were identified by soils

engineers from field observations of disturbed samples. Laboratory inspection and testing of dredged material samples and the inspection of voucher specimens of vegetation supplemented the field identifications.

Following review of the field data, one generalization can be made: the smaller the confined disposal area, the more rapidly ecological development of the disposal site will occur. The ecological development depends on the size of the site, substrate, and frequency and location of the deposition of dredged material on the site. For example, large disposal areas are repeatedly used and vegetation succession is arrested in an early stage. Larger disposal sites also make colonizers more remote to the majority of the site. If the larger areas are partitioned by diking, deposition in one of the smaller plots will not influence succession in adjacent confinements. An exception would be seepage of water through the dikes. The lower portions of dikes would be saturated, which in turn does affect succession.

Seasonal variations within the five study regions influence habitat, which in turn influences the prediction of the expected type of revegetation and rates of maturation. Permeability, nutrients, and other physical and chemical parameters of the dredged material were considered along with possible variations in the depth of filling.

Presented in this report (Part III) are alternative disposal techniques to enhance wildlife habitats. These alternatives are first tailored, in a general sense, to the five regions of study. Extrapolation of these methods is made from one geographic area to another. The aim is to present to the Corps District offices a group of enhancement alternatives for multiple wildlife use of disposal sites. General constraints to enhancement alternatives are noted. The expected biological successional patterns, based on the reconnaissance of 15 sites, are presented for each of the 5 regions.

Five of the 15 sites, one from each of the 5 regions, were selected as potential test sites to demonstrate the recommended alternatives of this report. For each of the five sites, specific application techniques for enhancement are discussed (Part IV). Schemes for partitioning the sites into smaller plots, rotation of disposal discharge locations, elimination of less desired vegetation, and drainage control of surface water are discussed. Habitats resulting from these schemes are postulated in this report. Management techniques, habitat requirements, and food preferences of target species are presented.

Environmental and economic costs and benefits of proposed alternate disposal techniques were categorized into short-term and long-term costs. Benefits were compared to the present costs.

The rationale for selection of the above 5 potential test sites includes a ranking of 13 factors for each site. A ranking of "poor", "neutral", or "optimum" is made for each factor. The results are presented in an evaluation matrix (Table 3). Persons and agencies contacted during this study are listed in Appendix A. A standardized field checklist used for these studies is presented in Appendix B of this report. Appendix C contains details of management techniques, habitat requirements, and food preferences for several wild-life species. A list of the common names for plants and animals mentioned in the report is presented in Appendix D along with the corresponding scientific name.

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PART I: INTRODUCTION

Background

1. The U. S. Army Engineer Waterways Experiment Station (WES) is planning and conducting a research program for the Office, Chief of Engineers (OCE) on the disposal of dredged material. The Dredged Material Research Program (DMRP) has as its objective to provide more definitive information on the environmental aspects of dredging and dredged material disposal operations and to develop technically satisfactory, environmentally compatible, and economically feasible dredging and disposal alternatives, including consideration of dredged material as a manageable resource.

2. For confined land disposal of dredged material, it is believed that through well conceived, planned, and executed multiple use schemes much adversity, both environmental and public, can be mitigated. Confined disposal areas can and already have, through largely unplanned efforts, provided suitable wildlife habitats. Often the disposal areas represent islands of undeveloped terrestrial habitat within the midst of urbanized areas.

3. Initial efforts under the research task are designed to investigate the compatibility of disposal area filling techniques and rates with immediate and long-range use requirements of wildlife. The ultimate goal is the planned use of disposal sites for a wide spectrum of wildlife

enhancement, with maintenance of basic compatibility with dredged material disposal requirements.

4. Agencies and/or persons other than Corps of Engineers District offices with jurisdiction over the sites which were studied are presented in Appendix A. Several suggestions as to specific habitats and resultant wildlife considered desirable for the region in question were discussed along with ongoing research and their opinions as to the viability of proposed enhancement schemes for dredged material disposal sites. The regional Environmental Protection Agency (EPA) offices were contacted to discuss the possibility of pending effluent disposal criteria applicable to dredged material.

Purposes

5. The purposes of the studies conducted under Contract DACW39-74-C-0033 were:

a. Review the present disposal practices of dredged material on confined (diked) land areas.

b. Identify alternate disposal techniques which may enhance the present wildlife habitats on disposal sites and yet be nonconflicting with the existing wildlife setting.

c. Select experimental sites to demonstrate alternate disposal techniques.

d. Establish that the proposed alternate disposal methods do not unduly conflict with the present maintenance dredging techniques and capabilities.

Scope

6. The scope of work conducted under this research project included:

a. Selection of CE Districts and potential sites to be studied within five regions of the United States: Great Lakes, North Atlantic Coast, South Atlantic Coast, Gulf Coast, and Pacific Coast.

b. Survey of the present disposal techniques used at 15 selected sites (3 sites within each of the 5 regions).

c. Identification of the type of wildlife habitat and dredged material characteristics of the 15 disposal sites by on-site field methods.

d. Conduction of minimal laboratory tests to aid in the identification of physical and chemical characteristics of dredged material.

e. Identification of alternate disposal techniques considered viable in improving wildlife habitats and use.

f. Selection of one site from each of the five regions for potential application of identified alternate disposal techniques.

PART II: SURVEY OF PRESENT DREDGED MATERIAL DISPOSAL AND WILDLIFE HABITATS

Selection of Study Areas

7. Studies were initiated during the Dames & Moore project control group meeting 22 October 1973. Five regions within the contiguous states were specified for study in the contract: Great Lakes, North Atlantic, South Atlantic, Gulf Coast, and Pacific Coast. Geographic boundaries for these regions were arbitrarily defined by the control group. Representative CE District offices were selected from each of these regions in which potential sites would first be considered. This selection was based on information from Boyd et al. (1972) related to:

a. The yearly quantity of dredged material incidental to maintenance dredging.

b. The variable characteristics of dredged material from each Corps District.

c. Use of confined disposal sites.

In the selection process, a diverse-as-possible geographic location of sites was kept in mind.

8. Eleven CE District offices were selected for site visits and discussions with persons familiar with the disposal operations:

Philadelphia	Norfolk
Savannah	Charleston

(continued next page)

Selected Sites (continued)

Mobile	New Orleans	Memphis
San Francisco	Portland	Detroit
Galveston		

Initial Site Visits

9. Visits were made during the week of 2 through 9 November 1973 by biologists and soils engineers. Their purpose was to select two to three disposal sites per District after discussions with CE personnel and to make a brief inspection of the sites.

10. Twenty-seven potential sites were selected during these initial visits. Ultimately 15 of these sites, 3 from each of the 5 study regions, were selected. Final selections were based on the location of site, expected ease of access, source and potential pollution of dredged material, frequency of deposition, available historical data of operations, diversity of wildlife habitat, and isolation from human activities. The size of the site, such that experimental plots would be available, and the dredged material research activities of the various CE Districts were also considered.

Site Investigations

Locations

11. Figure 1 presents the arbitrary outline of the five study regions along with general locations of the 15 sites shown with respect to state boundaries. Vicinity maps,

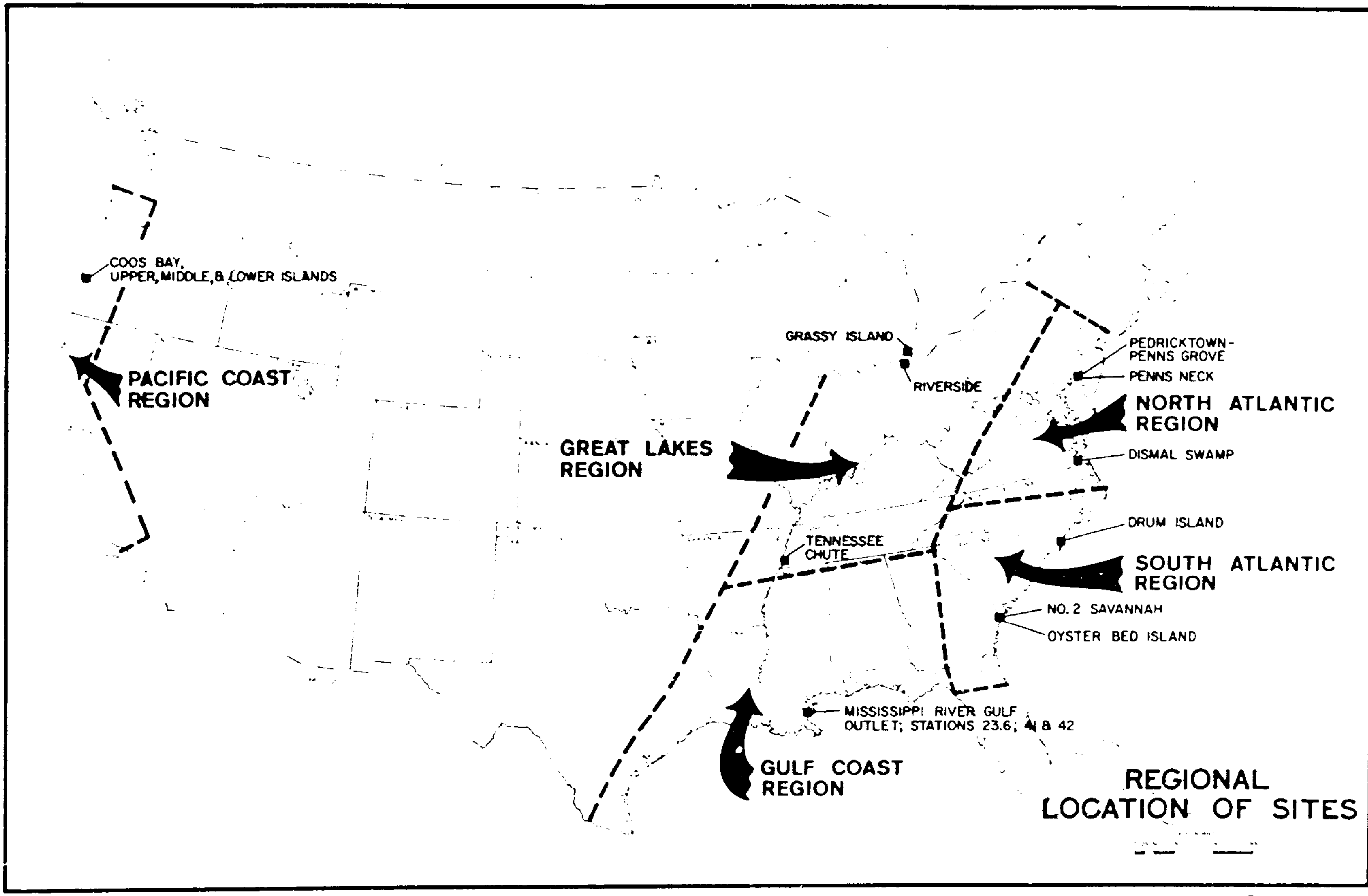
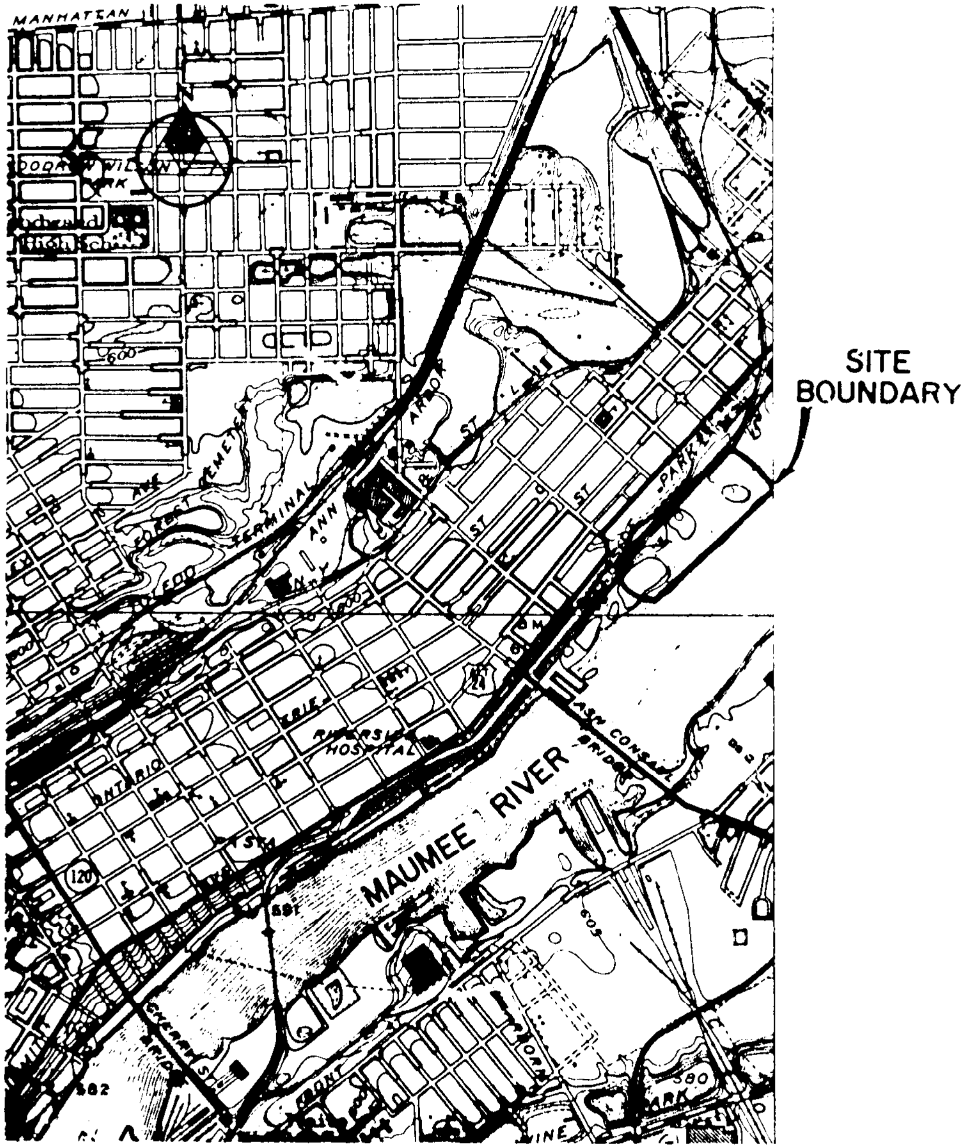

COOS BAY,
UPPER, MIDDLE, & LOWER ISLANDS
PACIFIC COAST REGION
GREAT LAKES REGION
GRASSY ISLAND
RIVERSIDE
TENNESSEE CHUTE
PEDRICKTOWN-PENNS GROVE
PENNS NECK
NORTH ATLANTIC REGION
DISMAL SWAMP
DRUM ISLAND
SOUTH ATLANTIC REGION
NO. 2 SAVANNAH
OYSTER BED ISLAND
MISSISSIPPI RIVER GULF OUTLET; STATIONS 23.6; 41 & 42
GULF COAST REGION
REGIONAL LOCATION OF SITES

FIGURE 1



REFERENCE:
UNITED STATES GEOLOGICAL SURVEY
TOLEDO QUADRANGLE
OHIO-MICHIGAN

VICINITY MAP
RIVERSIDE

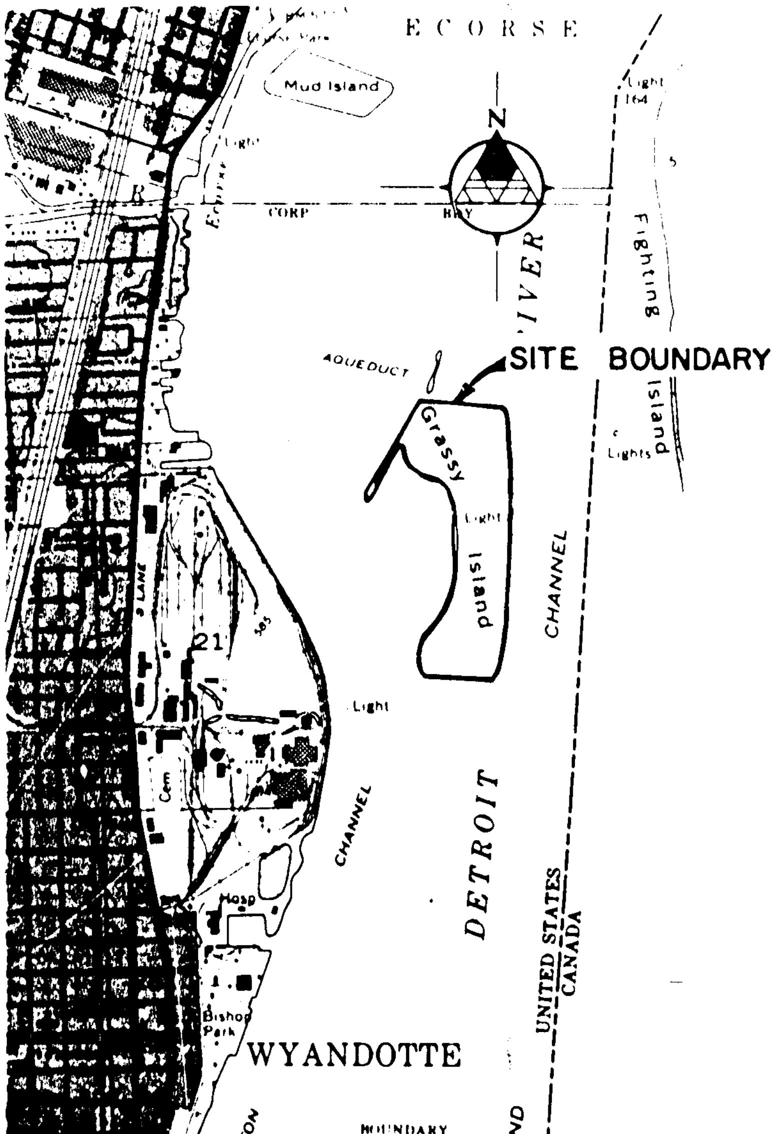
DETROIT DISTRICT

SCALE 1:24000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER



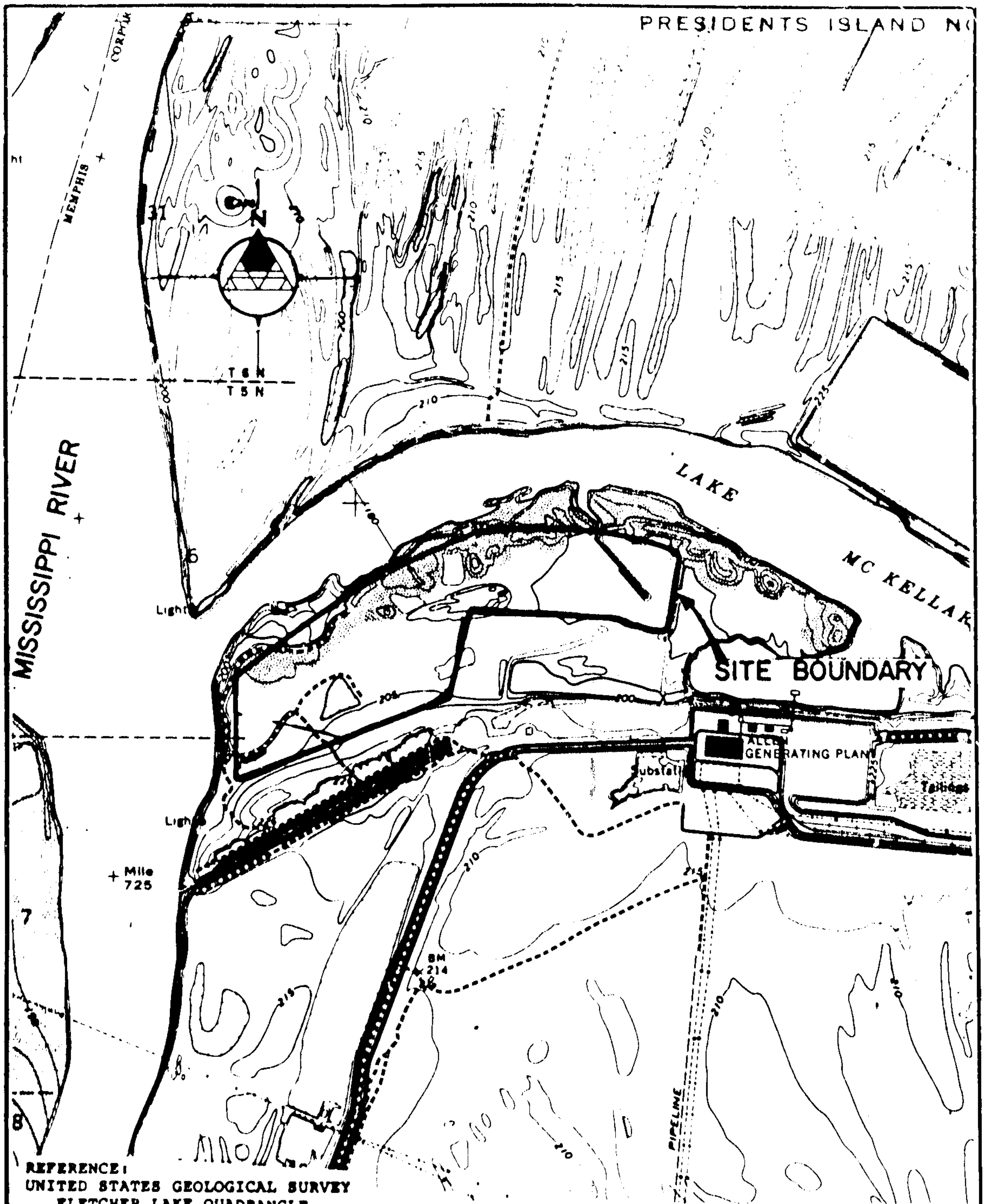
REFERENCE:
UNITED STATES GEOLOGICAL SURVEY
WYANDOTTE QUADRANGLE
MICHIGAN-ONTARIO

VICINITY MAP
GRASSY ISLAND

DETROIT DISTRICT

SCALE 1:24000

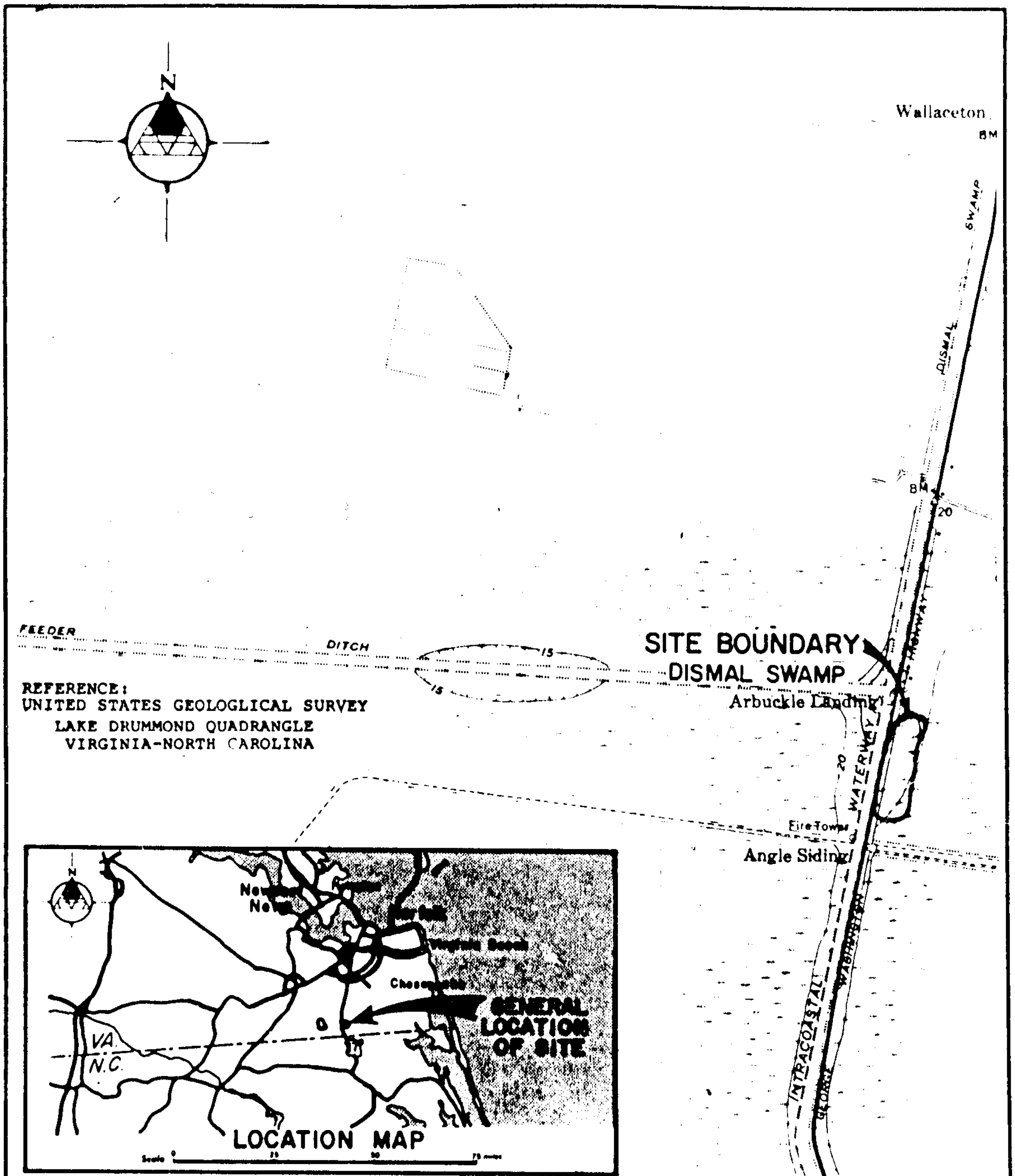
FIGURE 3



VICINITY MAP
TENNESSEE CHUTE
MEMPHIS DISTRICT

SCALE 1 24000

FIGURE 4

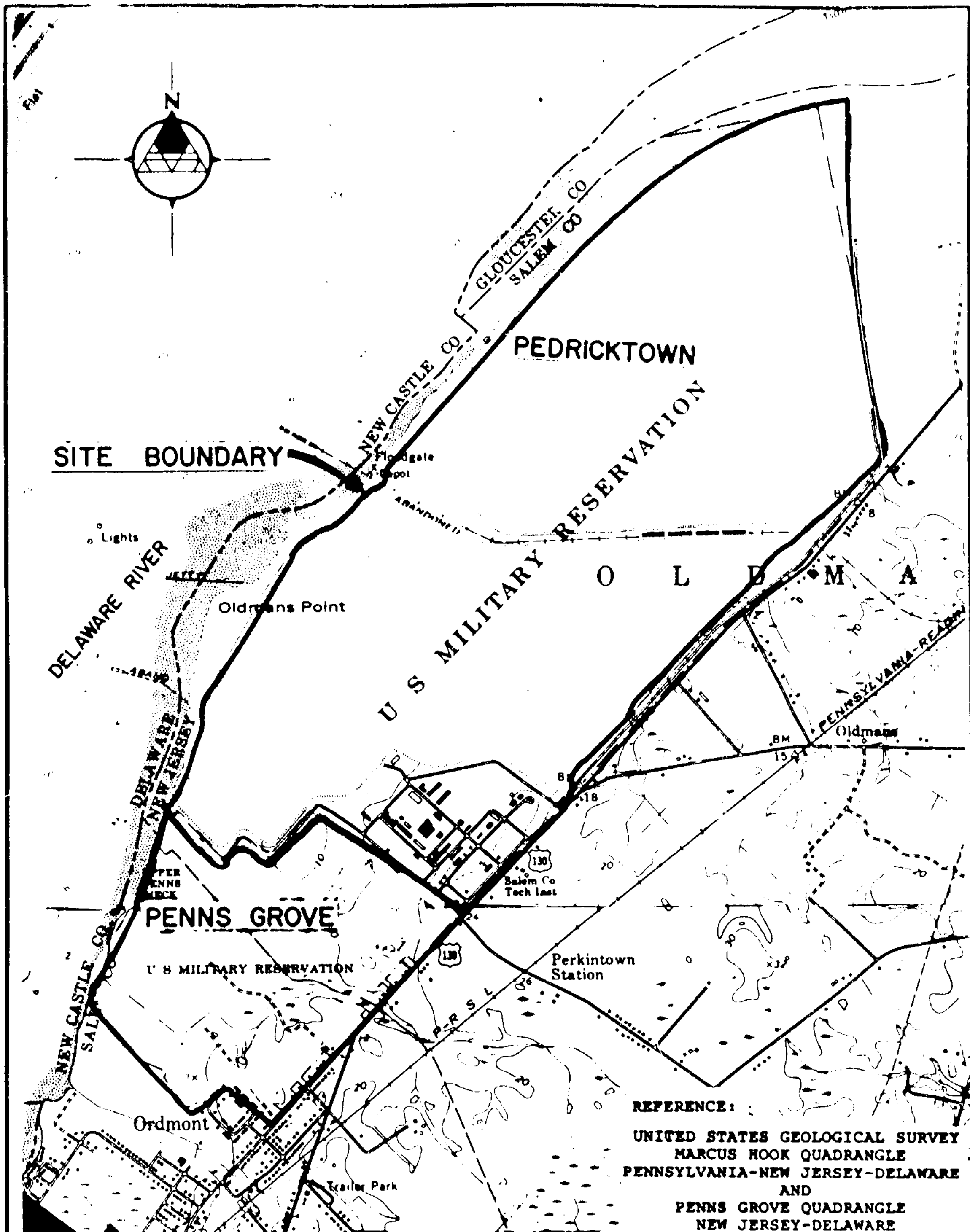


VICINITY MAP
DISMAL SWAMP

NORFOLK DISTRICT

SCALE 1:24 000

FIGURE 5



VICINITY MAP
PEDRICKTOWN - PENNS GROVE SITE
PHILADELPHIA DISTRICT
SCALE 1:24000

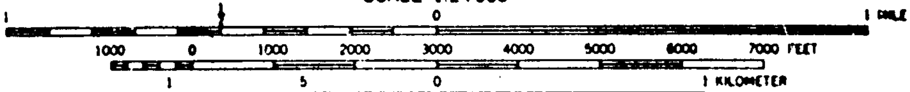
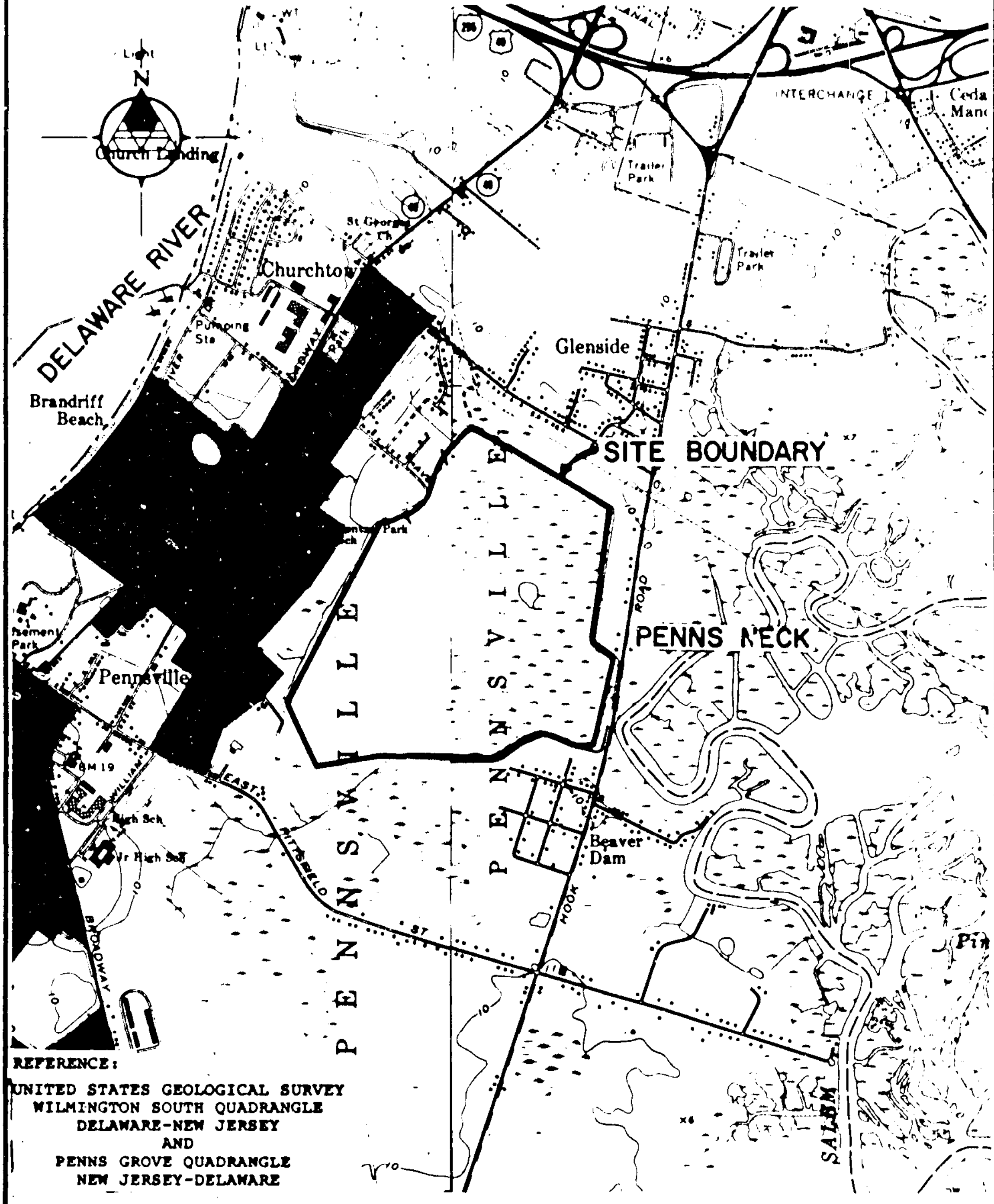


FIGURE 6



VICINITY MAP
PENNS NECK
PHILADELPHIA DISTRICT

SCALE 1:24 000

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 KILOMETER

FIGURE 7

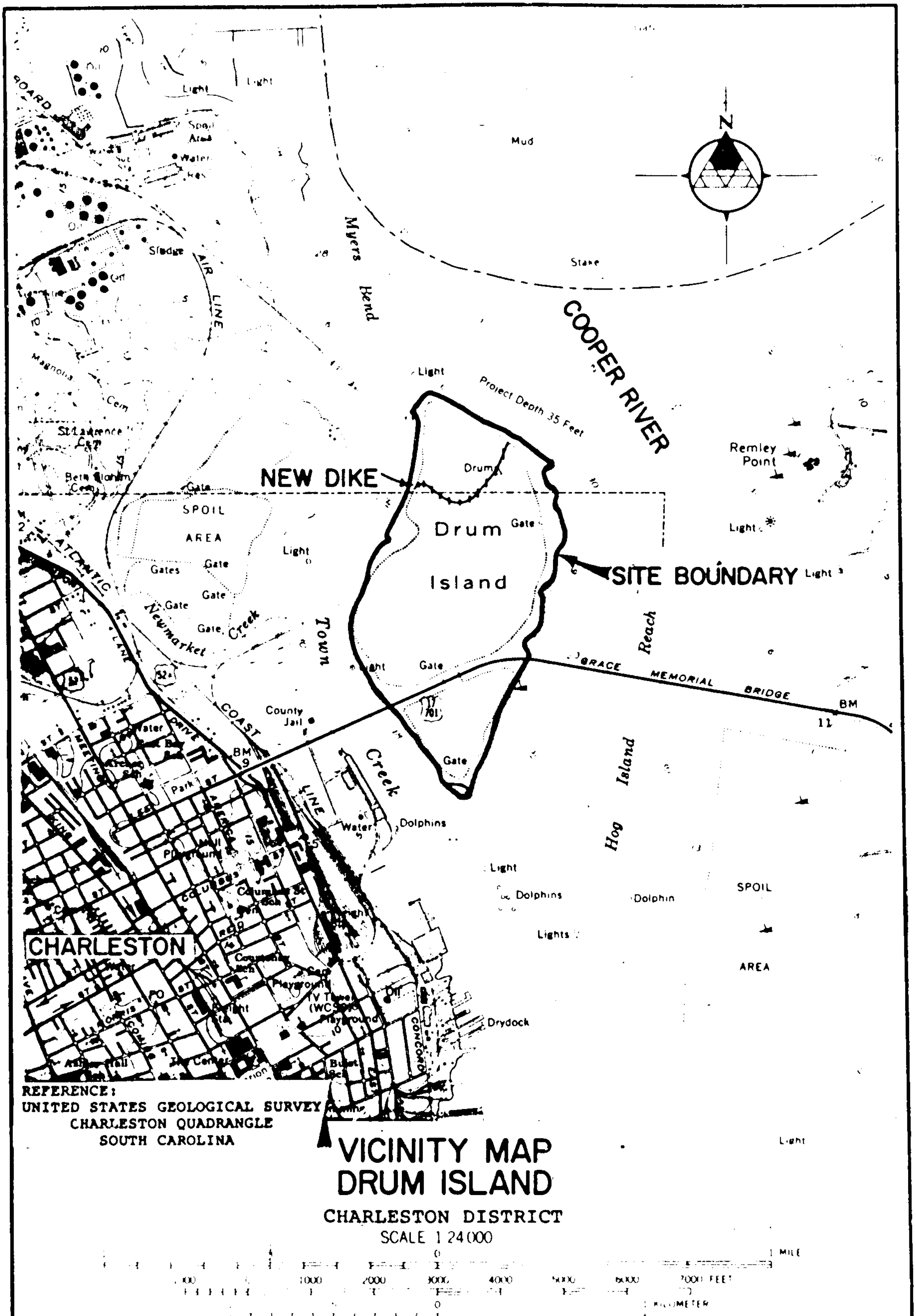
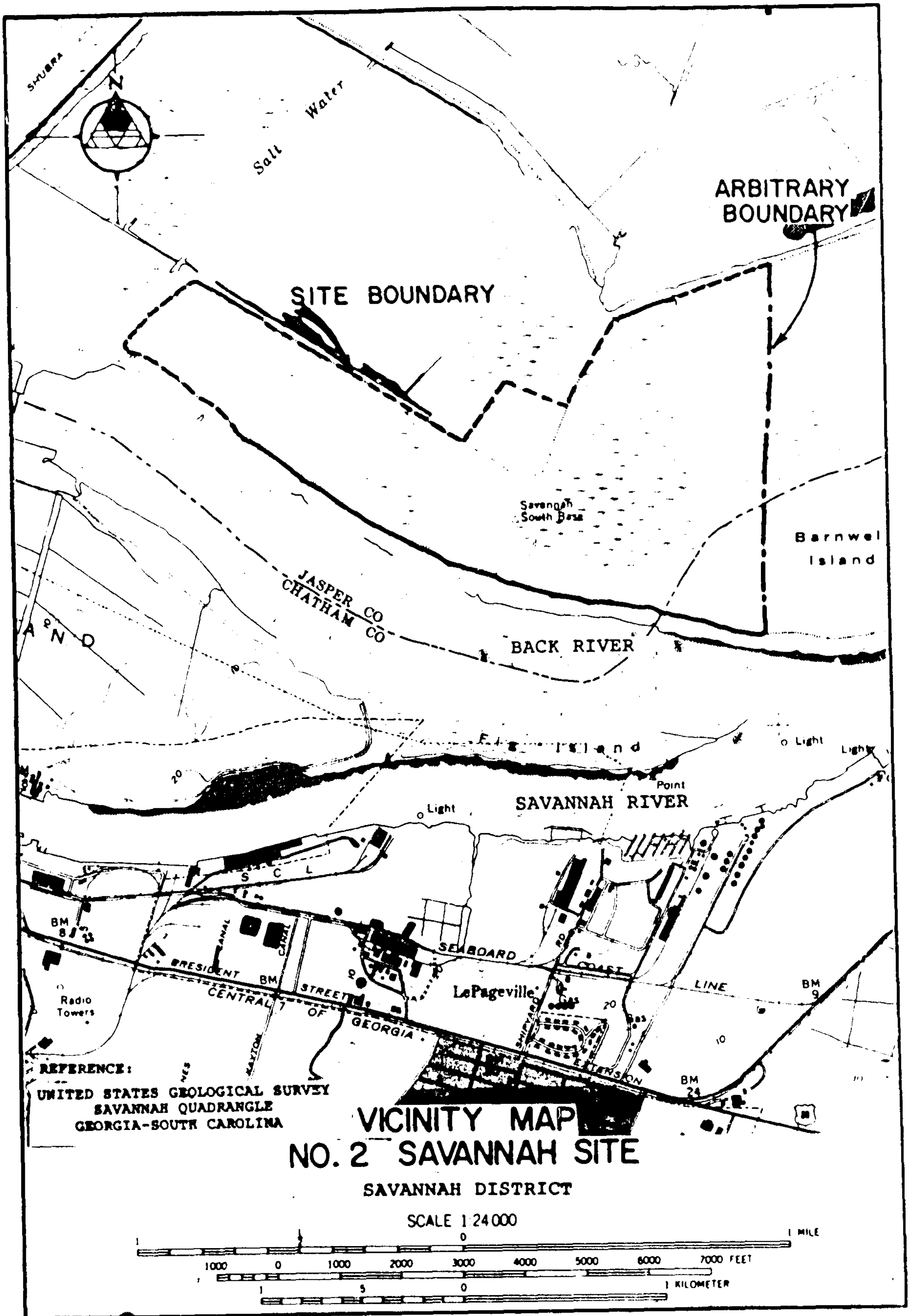
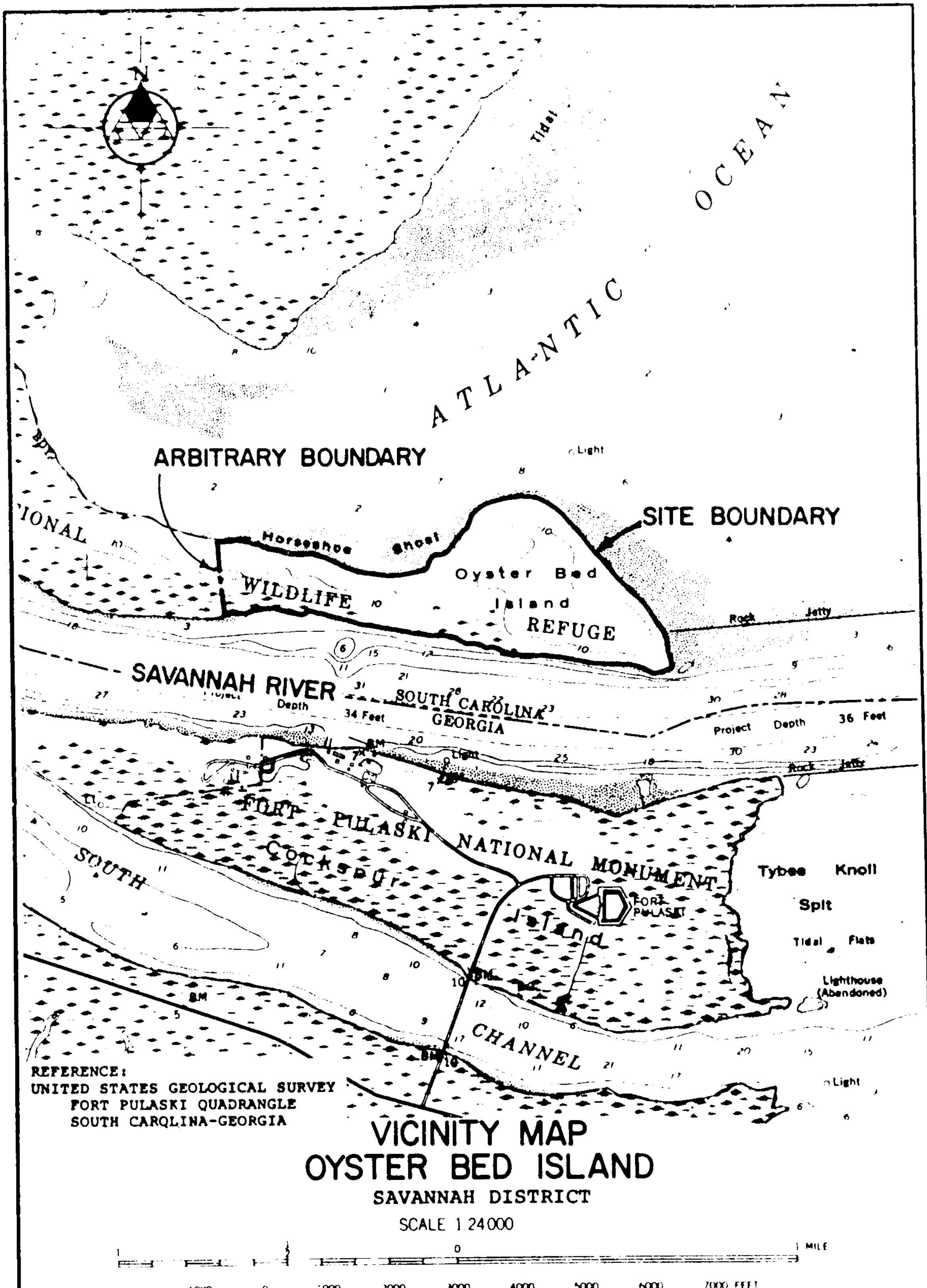

COOPER RIVER
NEW DIKE
SITE BOUNDARY
Drum Island
Project Depth 35 Feet
Myers Bend
Town Creek
Hog Island Reach
Remley Point
SPOIL AREA
GRACE MEMORIAL BRIDGE
CHARLESTON
County Jail
Dolphins
Drydock
Mud
Stake
Light
Gate
N
REFERENCE:
UNITED STATES GEOLOGICAL SURVEY
CHARLESTON QUADRANGLE
SOUTH CAROLINA
VICINITY MAP
DRUM ISLAND
CHARLESTON DISTRICT
SCALE 1:24 000
1 MILE
1000
2000
3000
4000
5000
6000
7000 FEET
1 KILOMETER

FIGURE 8



N
Salt Water
ARBITRARY BOUNDARY
SITE BOUNDARY
Savannah South Base
Barnwell Island
JASPER CO
CHATHAM CO
BACK RIVER
Light
Point
SAVANNAH RIVER
S C L
BM 8
SEABOARD
PRESIDENT STREET
CENTRAL OF GEORGIA
LePageville
COAST LINE
BM 9
Radio Towers
EXTENSION
BM 24
REFERENCE:
UNITED STATES GEOLOGICAL SURVEY
SAVANNAH QUADRANGLE
GEORGIA-SOUTH CAROLINA
VICINITY MAP
NO. 2 SAVANNAH SITE
SAVANNAH DISTRICT
SCALE 1:24000
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER

FIGURE 9

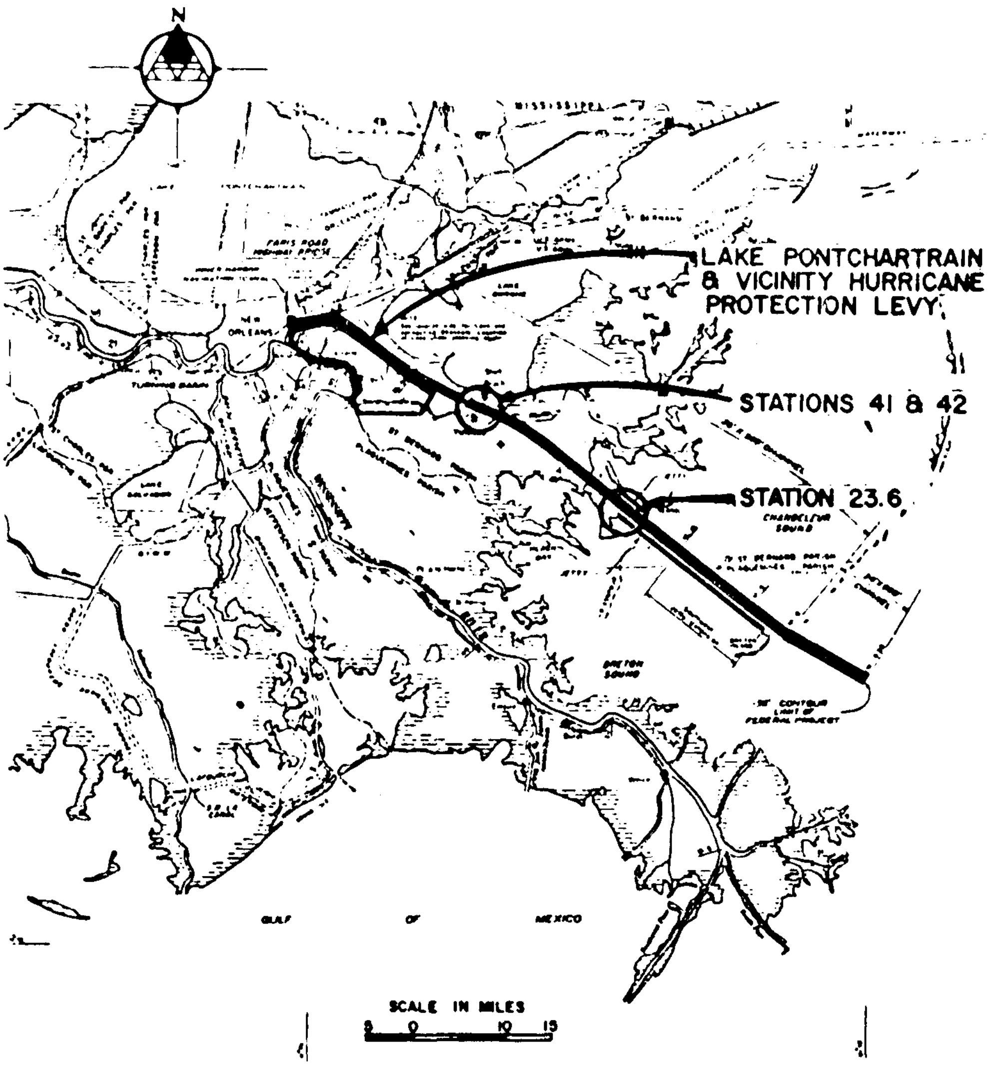


VICINITY MAP
OYSTER BED ISLAND

SAVANNAH DISTRICT

SCALE 1:24000

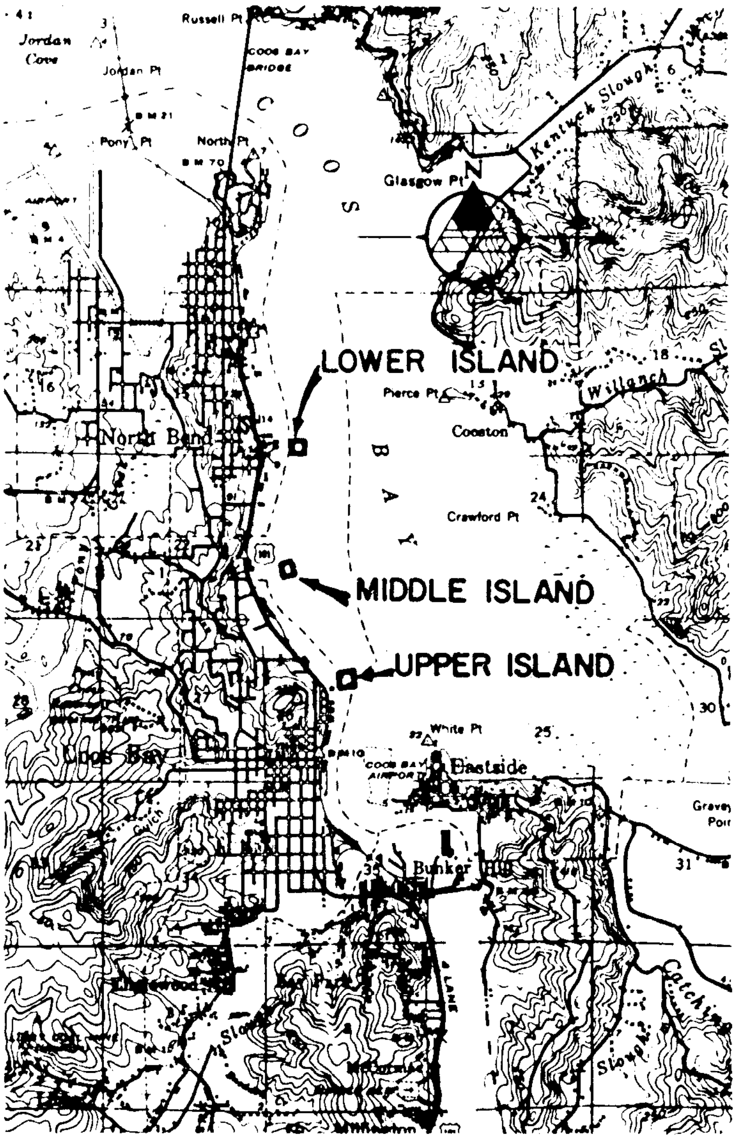
FIGURE 10



VICINITY MAP
MISSISSIPPI RIVER GULF OUTLET SITES (MRGO)
STATIONS 23.6, 41, & 42

NEW ORLEANS DISTRICT

FIGURE 11



REFERENCE:
UNITED STATES GEOLOGICAL SURVEY
COOS BAY QUADRANGLE
COOS BAY, OREGAN

VICINITY MAP
COOS BAY SITES
UPPER, MIDDLE, & LOWER ISLANDS

PORTLAND DISTRICT

SCALE 1:62500

FIGURE 12

presented in Figures 2 through 12, show the sites with respect to surrounding topographic, hydrologic, and man-made features. Figure 1, not prepared from U. S. Geological Survey (USGS) topographic sheets, only illustrates the locations of sites at Stations 23.6, 41, and 42 along the Mississippi River Gulf Outlet. Listed are the site names and locations:

a. Great Lakes Region.

<u>Detroit District</u>: "Riverside" located along the north bank of the Maumee River in Toledo, Ohio, and "Grassy Island" located in the west portion of the Detroit River near Wyandotte Ranch, Wyandotte, Michigan.

<u>Memphis District</u>: "Tennessee Chute" located on the east side of the Mississippi River near Memphis Harbor in Memphis, Tennessee

b. North Atlantic Region.

<u>Norfolk District</u>: "Dismal Swamp" located just south of Portsmouth, Virginia.

<u>Philadelphia District</u>: "Pedricktown-Penns Grove," New Jersey, located about four miles east of Wilmington, Delaware, and "Penns Neck," about four miles southwest of the aforementioned site.

c. South Atlantic Region.

<u>Charleston District</u>: "Drum Island" in Charleston Harbor, South Carolina, near the Wando River

Outlet. The Cooper River Bridge crosses the Drum Island site.

Savannah District: "No. 2 Savannah" on the Back River, across from Savannah, Georgia, and "Oyster Bed Island" near the outlet of the Savannah River across from Fort Pulaski Monument, about six miles southwest of Hilton Head, South Carolina.

d. Gulf Coast Region.

New Orleans District: "Mississippi River Gulf Outlet" (MRGO) sites corresponding to Stations 23.6, 41, and 42. The stations correspond to river miles upstream from the Gulf of Mexico.

e. Pacific Coast Region.

Portland District: "Upper, Middle, and Lower Islands" in Coos Bay near Coos Bay and North Bend, Oregon.

Field Study Methods

12. The objective of the inspection of the 15 sites was to obtain basic operational parameters and limitations of dredging techniques, both from first hand observation and from interviews with CE personnel familiar with the District dredging. If a particular rationale for present disposal methods was used, this too was to be noted. Field studies were conducted between the weeks of 9 November and 31 December 1973. For each site, vegetation remaining from the

fall foliage and/or winter specimens were documented as well as any observed wildlife. Dredged material within the confined sites was also classified according to grain size.

13. A standardized checklist was prepared for the field studies (see Appendix B) to establish, as much as possible, a uniformity of information to be gathered. This was to provide a more rational and equitable basis for selection of experimental test areas. The duration of site visits by the regional study teams was between 1.5 and 2.5 days. Longer time was spent if inclement weather or restricted access prohibited field work. CE personnel contacted during the initial site visits were again interviewed about dredging operational parameters and limitations. Operational parameters included types of dredging equipment and variations of equipment. Limitations included equipment types and size, present use of the site, rates of filling, site size and availability of land on site or nearby, type and system of diking, frequency and duration of disposal, and the depth of placement. Questions were also asked about restrictions of an economic, equipment, and/or legal nature.

14. Each site was surveyed to determine the plant species and community types present. Two perpendicular transects were established on the disposal areas. The primary transect line, generally trending north to south, originated, if possible, at the pipe discharge point and proceeded in a direction which covered the most pronounced stands of

vegetation or along a defined surface gradient. The direction of the primary transect was at most times the same as the direction of dredged material leaving the pipe. A secondary transect, perpendicular to the primary transect, but not necessarily bisecting, was run for added information.

15. The transect stations were marked by wooden stakes. Each station marker was labeled with the transect name and the distance from the origin. A compass heading was made to assist in determining the location of the transect line for photographic references.

16. These transects, which were used to evaluate the floral distribution patterns, varied in length with station intervals from 5 to 50 m. The frequency of sampling increased near the transition areas of various habitats. Samples were taken in the central portions of apparently homogeneous regions to confirm their homogeneity.

17. Herbaceous strata data were obtained from each station. The herb layer was determined in a 0.5 by 2 m rectangle centered along and perpendicular to the transect line. Within each rectangle the plant species were identified and an evaluation of their approximate percent coverage, according to the Braun-Blanquet Scale of Cover (Phillips 1959), was determined for each species. The herbaceous layer was defined as vegetation less than 1.3 m tall or plants which had a dbh less than 2.5 cm. This included woody vegetation as well as herbaceous species. This method

uses the total percent coverage as well as the abundance of individual plants within each species. Since the 0.5 by 2 m rectangle may have several layers of vegetation, it was possible to have a total percent cover in excess of 100 percent. Some interpretation was necessary in areas where the vegetation was dead or decumbent during the winter season. The tree strata were determined at each station from a 2 by 10 m quadrant also aligned perpendicular to the transect. All tree canopies in the quadrant were included disregarding the origin of trunk or stems.

18. Specimens unidentified in the field were collected for future identification. Voucher specimens were sent to the EEL. Photographs were taken in major habitat areas. Concurrently, faunal sightings and signs were noted and recorded. Transects were not taken at Grassy Island and Penns Neck because the dredged material was covered with water and/or very soft. At these sites, peripheral and representative samples were taken in lieu of transect data. Secondary transects were not taken at Riverside, Tennessee Chute, Pedricktown-Penns Grove, and Drum Island.

19. Dredged material, corresponding to vegetational transitions, was classified from field inspection by a soils engineer according to the nomenclature of the Unified Soil Classification System (Terzaghi and Peck 1967). Besides color and grain-size descriptions, permeability, relative compressibility, density, and organic content were estimated.

Hand augers were used to obtain representative disturbed samples (about 150 g) of the dredged material from the surface to an average depth of 0.5 m.

20. The samples were placed in airtight plastic bags and shipped to the Dames & Moore San Francisco office where they were stored in a moisture-controlled vault until tested. No samples of dredged material were taken other than on site. For example, channel or river sediment proximal to the site and the likely source of future site deposition was not a part of the sampling and testing program.

Laboratory Test Methods

21. Fourteen representative disturbed samples of dredged material were selected for laboratory tests. The purposes of these tests were to supplement field classifications and to determine certain chemical properties. Number of samples tested and sites were as follows:

Pedricktown-Penns Grove (1)

Penns Neck (3)

No. 2 Savannah (3)

Tennessee Chute (2)

Drum Island (1)

Oyster Bed Island (1)

Upper Island, Coos Bay (3).

Samples from other sites were not tested, either because of available historic data (Riverside and MRGO), or sampl s were not available, such as the Dismal Swamp and Grassy Island sites.

22. Gradation tests of the dredged material were performed to more specifically define the particle distribution and classification. The tests were also examined for estimates of the relative coefficient of perm ability. Gradation tests on cohesionless materials, gravels to sands (about 100 mm to 0.06 mm in average diameter) plus shell fragments, were conducted by mechanical sieve-analysis methods, according to the American Society of Testing and Materials (ASTM) test designation D422-63. In conducting the tests, a standard series of sieves were nested together and the retained weights of material, as percentage of a known initial total dry weight, were measured.

23. For cohesive, very fine-grained materials classified as silts to clays (0.60 mm to less than 0.002 mm), hydrometer test methods were used. These were also done according to ASTM D422-63. This test applied Stokes' Law to distinguish the relative particle size rates of falling through distilled water.

24. The natural moisture content of the 14 samples was determined according to ASTM D2216-66. Test results are expressed as a ratio of the weight of water to the dry weight of sample.

25. Six different chemical tests were conducted for each of the 14 bag samples. These were performed by Pacific

Environmental Laboratory, San Francisco, California. Tests were for soluble nitrate nitrogen (NO_3^-), pH, volatile fraction, ash content, chloride (Cl^-), and soluble carbonate. All chemical tests were conducted according to "Standard Methods for the Examination of Water and Waste Water" (A.P.H.A. 1965), and "Agricultural Handbook No. 60" (U.S. Gov. 1954). The chemical and physical tests of sediments were to establish correlations with specific plant assemblages, if possible. This knowledge can be used to modify sediments so that selected plant species could be supported. The soluble nitrogen test was performed to give an indication of the amount of nitrogen available to plants. This macronutrient, usually required in concentrations greater than 1 mg/l (Curtis and Clark 1950), is a basic component of chlorophyll, proteins, and other essential biochemical compounds. More soils have nitrogen deficiencies than other nutrient deficiency (Allison 1957). Such deficiencies are manifested in retarded growth and chlorosis of leaves. Conversely, an excess of nitrogen can lead to the development of a poor root system and the retardation of flowering and seed formation (Salisbury and Ross 1968).

26. Most plant species grow best in a range of pH 5 to 7, although plant growth is known in the range of pH 4 to 5. Imbalances in the acidity or alkalinity of soils can interfere with proper absorption of nutrients from soil by plant roots. For example, pH can affect salt absorption when hydroxyl or

bicarbonate ions present at higher pH's compete with anions (NO_3^-, Cl^-, $PO_4^{\equiv}$) and prevent these from being absorbed into the plant (Salisbury and Ross 1968). The pH is especially important to consider as marsh soils (Edelman and Van Staveren 1958) and some lake sediments (Ruttner 1952) are in an anaerobic reduced condition and rapidly oxidize when exposed to air. The acidic condition of the material after oxidation, particularly the oxidation of hydrogen sulfide, can be corrected by addition of appropriate quantities of lime should such reduced sediments be encountered in dredged materials.

27. The volatile fraction tests were performed to determine the percent of organic materials, including humus, which are essential in good soil. The organic compounds are decomposed into inorganic forms with a subsequent release of nitrogen and phosphorus, all of which are essential for plant growth. The organic materials themselves are media for base exchange and are important for maintaining a loose, friable soil texture (Broadbent 1957).

28. Ash content gives an indication of the amount of minerals present in the soil. Minerals required in large amounts (greater than 1 mg/l) are potassium, calcium, and magnesium. Micronutrients (less than 1 mg/l) required are iron, manganese, zinc, copper, molybdenum, boron, and chlorine (Curtis and Clark 1950).

29. Chlorine, usually present in the anionic form (Cl^-), is important (as an enzyme activator) for the stimulation of photosynthesis. Symptoms of chlorine deficiency are wilted leaves, chlorotic and necrotic leaves, and stunted roots (Salisbury and Ross 1968). Since chlorine is a component of some of the most common salts, a measure of chloride would be an indication of the salinity of soils.

30. Carbonate tests were performed. An excess of carbonates in the soil can interfere with iron metabolism and lead to iron chlorosis (Holmes and Brown 1957).

Results of Field Studies

31. A summary of the field studies is shown in Table 1. The physical features of the disposal sites, dredge types and operations, frequency of depositions, types of dredged material, and ecological and biological potential as a test area are presented in the following paragraphs. Discussion of legal constraints and assessments is also presented.

32. In all cases, some of the information requested on the field checklist (Appendix B) could not be supplied. Most missing information was related to engineering or equipment parameters. History of the stability and settlement of dikes; the number of locations of discharge to a site; an estimate of the density (pcf) of dredged material during transportation and after deposition; and a comparison of past and present pollution characteristics of dredged material were not available from discussions with CE personnel.

TABLE I- SUMMARY OF FIELD STUDIES

Region	Site & Location of Nearest City	Inland or Island	Acres (Approximate)	Elevation (MSL) (Average)	Total Feet of Dredged Material	Dredge Type	Cubic Yards per Work Shift (Average)	Number of Discharge Locations	Dredge Capacity	Type of Discharge	Maximum Miles from Disposal Site	[illegible]	Years of Use	Date of Last Deposition	Frequency of Use Past Months	Classification U.S.C.S. (a)	General Habitat Type	% of Site Inundated (12/73)	Feet of Tidal Influence	Successional State of Vegetation	Mammals & Birds	Potential for Testing Habitat Enhancement
Great Lakes	Riverside, Toledo, Ohio	Inland	20	570	26'	Hopper	630-2700	2	630-2700 CYS.	Open Pipe	1	1-2	5	3/72	12-24	CL / SM	Upland Terrestrial	-	N/A	Scrub-young hardwood	[illegible]	[illegible]
	Grassy Island, Wyandotte, Mich.	Island	72	590	20'	Hopper	700	4	300 CYS.	Open Pipe	1	1-2	13	12/73	6-9	ML / SC	Upland Terrestrial	[illegible]	N/A	Scrub, old field, early stage marsh	[illegible] birds, sparrows	[illegible]
	Tennessee Chute, W. Memphis, Tenn.	Inland	250	205	35'	Hydraulic Pipeline	20,000	3	30" Dia. Pipe	Open Pipe	.5	1	21	11/73	6-12	ML / SP	Lowland Terrestrial Freshwater Aquatic Freshwater Wetland	90	N/A	Freshwater pond	Aquatic birds, perching birds	[illegible]
North Atlantic	Dismal Swamp, Portsmouth, Va.	Island	7	5-12	5'	Hydraulic Pipeline	13,000	5	12" Dia. Pipe	Open Pipe	1	1-2	8	10/72	6-12	CH / SP	Upland Terrestrial	3	N/A	Scrub-young hardwood	Migratory birds	Neutral
	Pedricktown-Penns Grove, Wilmington, Del.	Inland	290	10	6	Hopper	3500	8	2500 CYS.	Open Pipe	1	8	8	None	6-12	ML / SM	Upland Terrestrial Freshwater	[illegible]	N/A	Freshwater pond, shrub, swamp, barrens	Water fowl	[illegible]
	Penns Neck, Wilmington, Del.	Inland	347	10	20'	Hopper	2500	3	2500 CYS.	Open Pipe	2	-	7	8/73	6-12	ML / SM	Lowland Terrestrial	3	N/A	Intermediate mature stage hardwood	Water fowl & other migratory birds, medium size mammals	[illegible]
South Atlantic	Drum Island, Charleston, S.C.	Island	155	3	6'	Hydraulic Pipeline	Not Avail.	2	18" Dia. Pipe	Open Pipe	.5	3	15	12/73	6-12	CL/CH / SP/SC	Upland Terrestrial	[illegible]	N/A	Scrub barren [illegible]	Migratory birds	Neutral
	No. 2 Savannah, Savannah, Ga.	Inland	600		10'	Hydraulic Pipeline	25,000	5	24" Dia. Pipe	Open Pipe	.5	1-1	1	12/70	3-12	CH / SP	Upland Terrestrial	5	N/A	Barren-scrub	Migratory birds	[illegible]
	Oysterbed Island, Savannah, Ga.	Island	625	5	15'	Hydraulic Pipeline	12000	10	18" Dia. Pipe	Open Pipe	.5	1-3	7	6/71	2-12	CL / SP	Upland Terrestrial	[illegible]	N/A	Scrub	Migratory birds	[illegible]
Gulf Coast	MRGO (b) STA. 23.6, New Orleans, La.	Inland	190		11'	Hydraulic Pipeline	32,000	3	1500 CYS/HR	Open Pipe	.2	2-6	8	10/68	6-9	CH/CL / SP/SC	Upland Terrestrial Marine Wetland (Edge)	60		Scrub young hardwoods	[illegible]	Neutral
	MRGO STA. 42, New Orleans, La.	Inland	155	6	9'	Hydraulic Pipeline	30,750	6	1700 CYS/HR	Open Pipe	.2	3-4	6	[illegible]/72	2-12	CL/CH / SP/SC	Upland Terrestrial Freshwater Wetland	[illegible]	Storm Periods	Barrens, old field (early stage)	[illegible]	[illegible]
	MRGO STA. 42, New Orleans, La.	Inland	204	6	9'	Hydraulic Pipeline	33,000	5	1600 CYS/HR	Open Pipe	.2	3-4	8	3/67	24-36	CH / SP	Upland Terrestrial	[illegible]	Storm Periods	Barrens	[illegible]	Neutral
Pacific Coast	Coos Bay Upper Island, Coos Bay, Ore.	Island	[illegible]	15	30'	Hydraulic Pipeline	22,000	4	24" Dia. Pipe	Open Pipe	.5	1	20	6/70	12-24	SP w/shells	Upland Terrestrial Marine Wetland	[illegible]		Old field (early stage) scrub	[illegible]	[illegible]
	Coos Bay Middle Island, Coos Bay, Ore.	Island	70	19	30'	Hydraulic Pipeline	10,000	3	20" Dia. Pipe	Open Pipe	.5	2	20	6/70	12-24	SP w/shells	Upland Terrestrial Marine Wetland	[illegible]		Old field (early stage)	[illegible]	Neutral
	Coos Bay Lower Island, Coos Bay, Ore.	Island	12	14	30'	Hydraulic Pipeline	10,000	1	20" Dia. Pipe	Open Pipe	.5	[illegible]	20	6/70	24-36	SP w/shells	Upland Terrestrial Marine Wetland	[illegible]		Barren	[illegible]	[illegible]

NOTE:

(a) UNIFIED SOIL CLASSIFICATION SYSTEM PRESENTED IN TERZAGHI AND PECK, 1967

(b) MISSISSIPPI RIVER GULF OUTLET STATION CORRESPONDS TO RIVER MILES FROM GULF OF MEXICO

33. Physical features. Seven of the 15 sites were islands wi. the other 8 being inland sites. The sites averaged about 200 acres and varied in size from 7 to 625 acres.

34. Dredge types and operations. Two types of dredges were used at the 15 disposal sites - hopper dredges and hydraulic pipeline dredges. The hopper dredges varied in volume from 300 to 2,700 cu yd. These were used at the Riverside, Grassy Island, Pedricktown-Penns Grove, and Penns Neck sites. At the remaining sites, hydraulic dredges with pipeline discharge diameters varying from 12 in. to 30 in. were used. The average depth of dredged material placed during a 24-hr work shift varied with the site size, number of discharge locations, and the dredged type. For hopper dredges, the average was 1.5 ft; for hydraulic dredges, the average was 3 ft. Poor to no records were available for incremental placement depths; therefore, these figures are considered very subjective. In all cases, disposal to the site was by open-end pipe. Not all of a site area was evenly covered during any one deposition with the exception of perhaps the smaller sites.

35. Frequency of deposition. The frequency of deposition varied from about six to nine months for the North Atlantic and the Gulf Coast sites to about 24 to 36 months at the Pacific Coast sites. The Pedricktown-Penns Grove site had no dredged material placed within the confines of

the Penns Grove part of the site. Dikes were being constructed during the field visit.

36. Dredged material. The dredged material types, as expected from maintenance dredging, were fine-grained, mostly silty clays and sands with combinations thereof. The sediment from the Coos Bay sites contained by far the largest amount of seashells and was predominantly fine to medium sand. Although efforts were made to assess potentially adverse chemical properties of the dredged material, both during the field sampling and during discussions with CE personnel, available information did not allow such assessments.

37. Engineering and equipment parameters. The method of disposal from each dredge, either hopper or hydraulic, is by pumping from the dredge through pipeline to the site. A disposal variation for the hopper dredge has been from the open-water bottom dumping to the direct pump-out to confined disposal sites. No new variations in equipment or disposal techniques from those discussed in Boyd et al. (1972) were sighted during the field reconnaissance.

38. The patterns and the rationale for disposal techniques are predicated on the availability of equipment and location of disposal site. The material, in the past, has been pumped and directly discharged to a site. Any alteration to this method hampers the efficiency of the dredge operation, which affects the economics of equipment life and job completion.

39. <u>Biological characteristics</u>. The general habitat types of the sites vary from upland terrestrial to both freshwater and marine wetlands. Some upland terrestrial habitat was found at all sites except Tennessee Chute (lowland terrestrial, freshwater aquatic, and wetlands) and Penns Neck (lowland terrestrial).

40. The successional state of vegetation, mammals, and birds of the sites are noted in Table 1. No mammals were observed at either of the M.R.G.O. sites or Coos Bay sites. The results of the vegetation transect studies are presented, along with plot plans showing locations of transects and sample areas, in Figures 13 through 47.

41. Animals populating the Grassy Island site are ducks (mallards and others) and small mammals such as mice and muskrats, as indicated by trails. The Riverside and Tennessee Chute sites had tracks and pellets of rabbits, along with sparrows, ring-necked pheasants, and mourning doves. Deer and turkey populate the Tennessee Chute site (Mr. A. B. Richardson, personal communication).

42. Ducks were seen on open water at Penn's Neck but no faunal signs were noticed, there or at Pedricktown-Penns Grove. Fauna and faunal signs observed at Dismal Swamp included sparrows, dark-eyed juncos, skunks, raccoons, deer, and moles. Marsh hawks, rabbits, and raccoons were present at No. 2 Savannah. Fauna on the Oyster Bed Island site was diverse. Besides marsh rabbits and raccoons there were Savannah

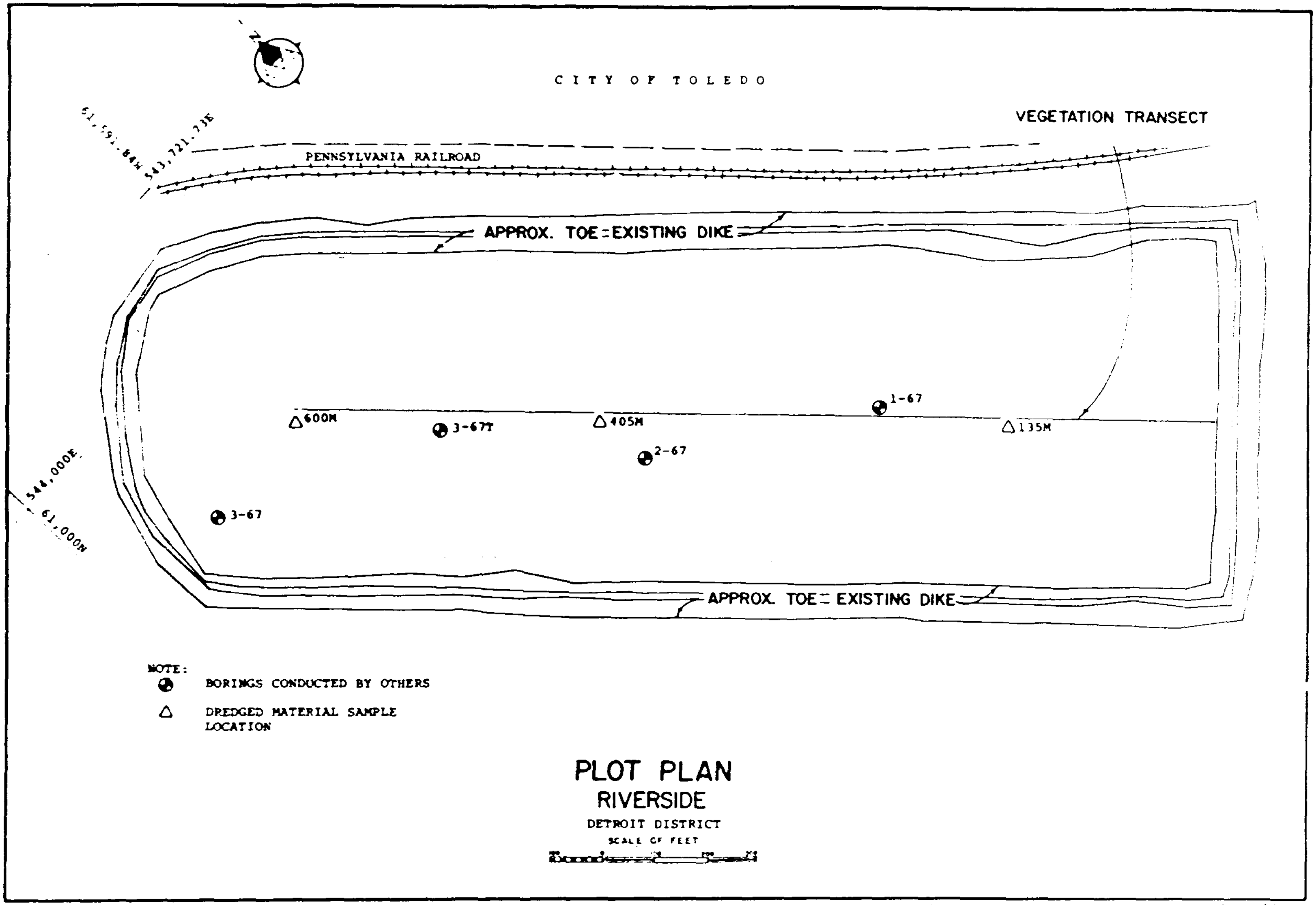
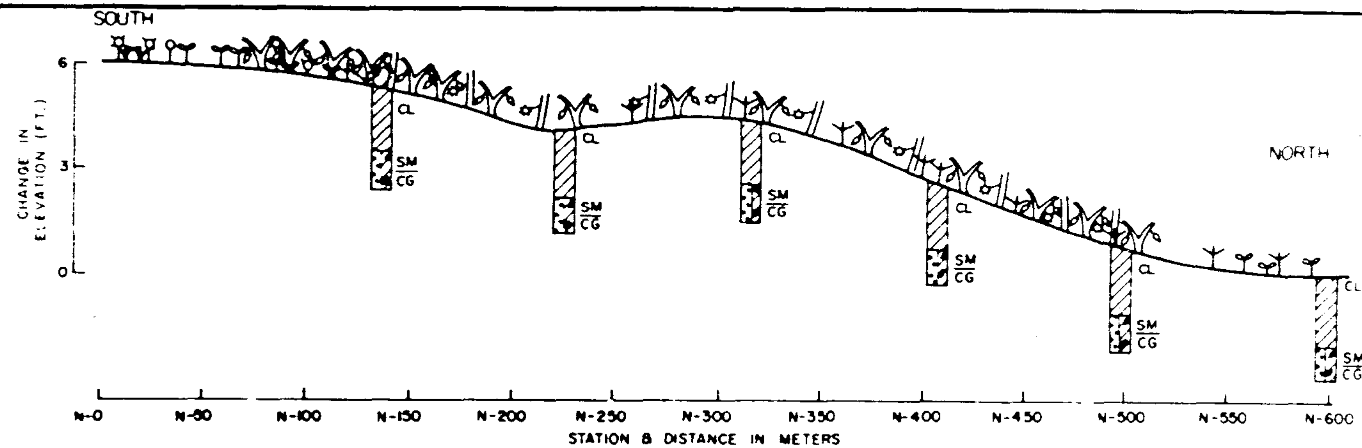

CITY OF TOLEDO
VEGETATION TRANSECT
PENNSYLVANIA RAILROAD
61,591.84N 543,721.73E
544,000E
61,000N
APPROX. TOE = EXISTING DIKE
APPROX. TOE = EXISTING DIKE
600M
3-67T
405M
2-67
1-67
135M
3-67
NOTE:
BORINGS CONDUCTED BY OTHERS
DREDGED MATERIAL SAMPLE LOCATION
PLOT PLAN
RIVERSIDE
DETROIT DISTRICT
SCALE OF FEET

FIGURE 13



TREE LAYER												
Willow		24 3 3	5 5	+	4	4	4	3	4 3	4 2		
Aspen			3	5	4	4	4	3	4 3	4 2		
HERB LAYER												
Smartweed	+33	2+2 33	22									2
Grass #3	+33 +											
Unknown #1	2											
Pigweed	+ + 2											
Composite #1	2	53	22								3 4	3 3
Composite #2		34 34 43	3 2									
Avens		+	3 3+	+	+	3	2	4	2 4	3 4	4 +	3
Cocklebur			+									
Common elder										+		
Curly dock												+
Unknown composite				3								

VEGETATION TRANSECT
RIVERSIDE

FIGURE

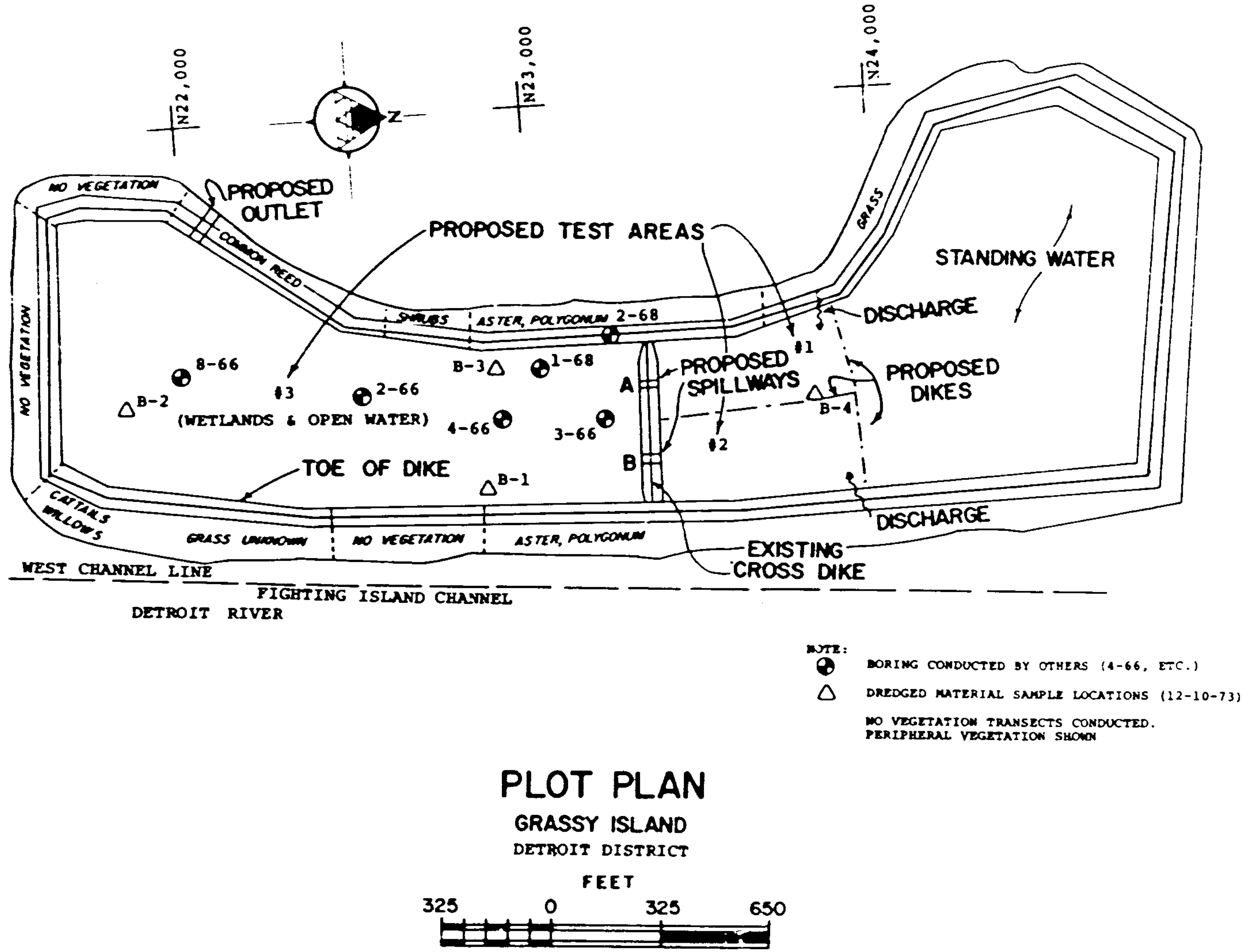
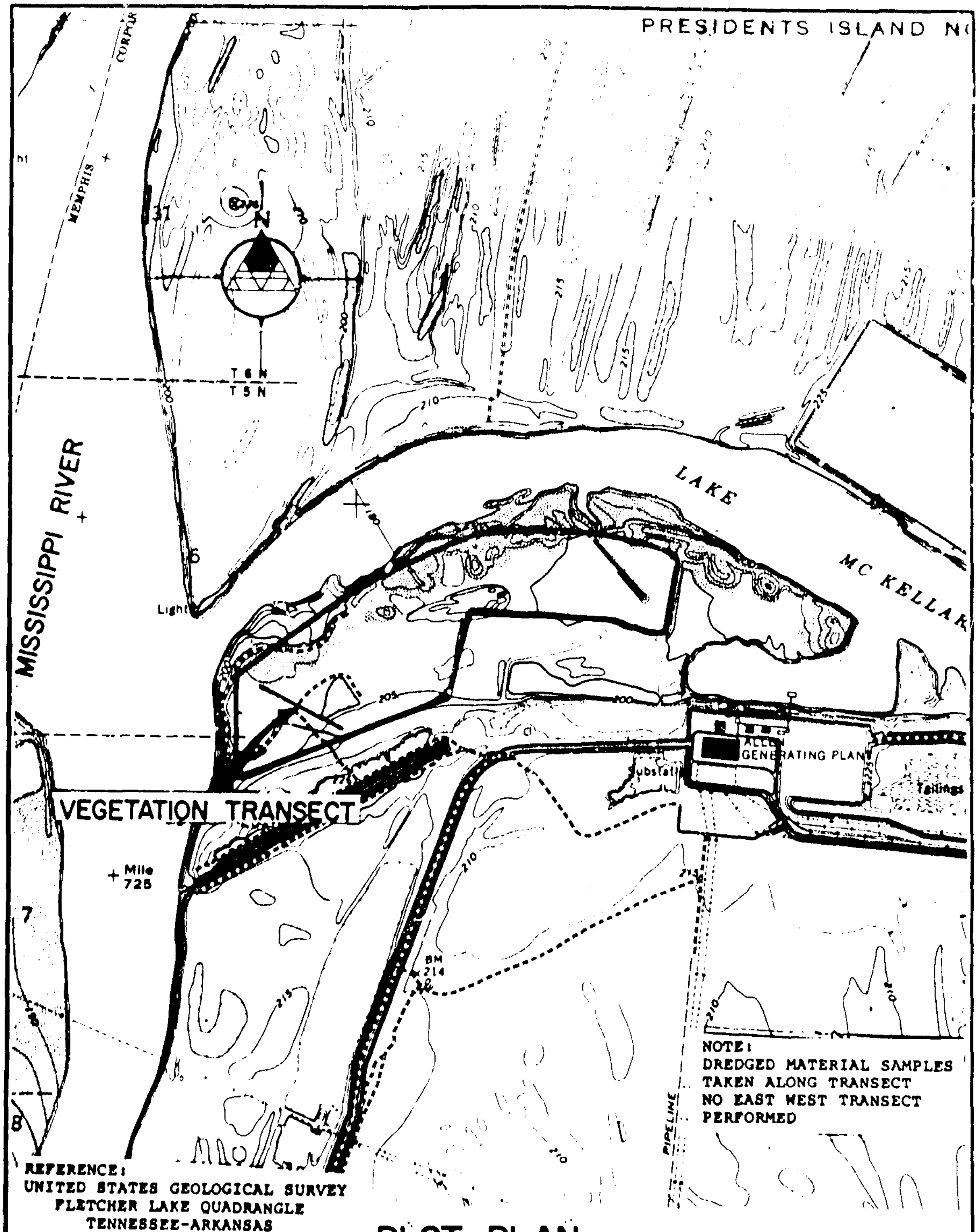

N22,000
N23,000
N24,000
N
PROPOSED OUTLET
NO VEGETATION
COMMON REED
PROPOSED TEST AREAS
SHRUBS
ASTER, POLYGONUM
2-68
GRASS
STANDING WATER
DISCHARGE
#1
PROPOSED SPILLWAYS
PROPOSED DIKES
B-4
A
B
#2
#3
8-66
B-2
2-66
B-3
1-68
4-66
3-66
(WETLANDS & OPEN WATER)
TOE OF DIKE
B-1
CATTAILS WILLOWS
GRASS UNKNOWN
NO VEGETATION
ASTER, POLYGONUM
DISCHARGE
EXISTING CROSS DIKE
WEST CHANNEL LINE
FIGHTING ISLAND CHANNEL
DETROIT RIVER
NOTE:
BORING CONDUCTED BY OTHERS (4-66, ETC.)
DREDGED MATERIAL SAMPLE LOCATIONS (12-10-73)
NO VEGETATION TRANSECTS CONDUCTED.
PERIPHERAL VEGETATION SHOWN
PLOT PLAN
GRASSY ISLAND
DETROIT DISTRICT
FEET
325
0
325
650

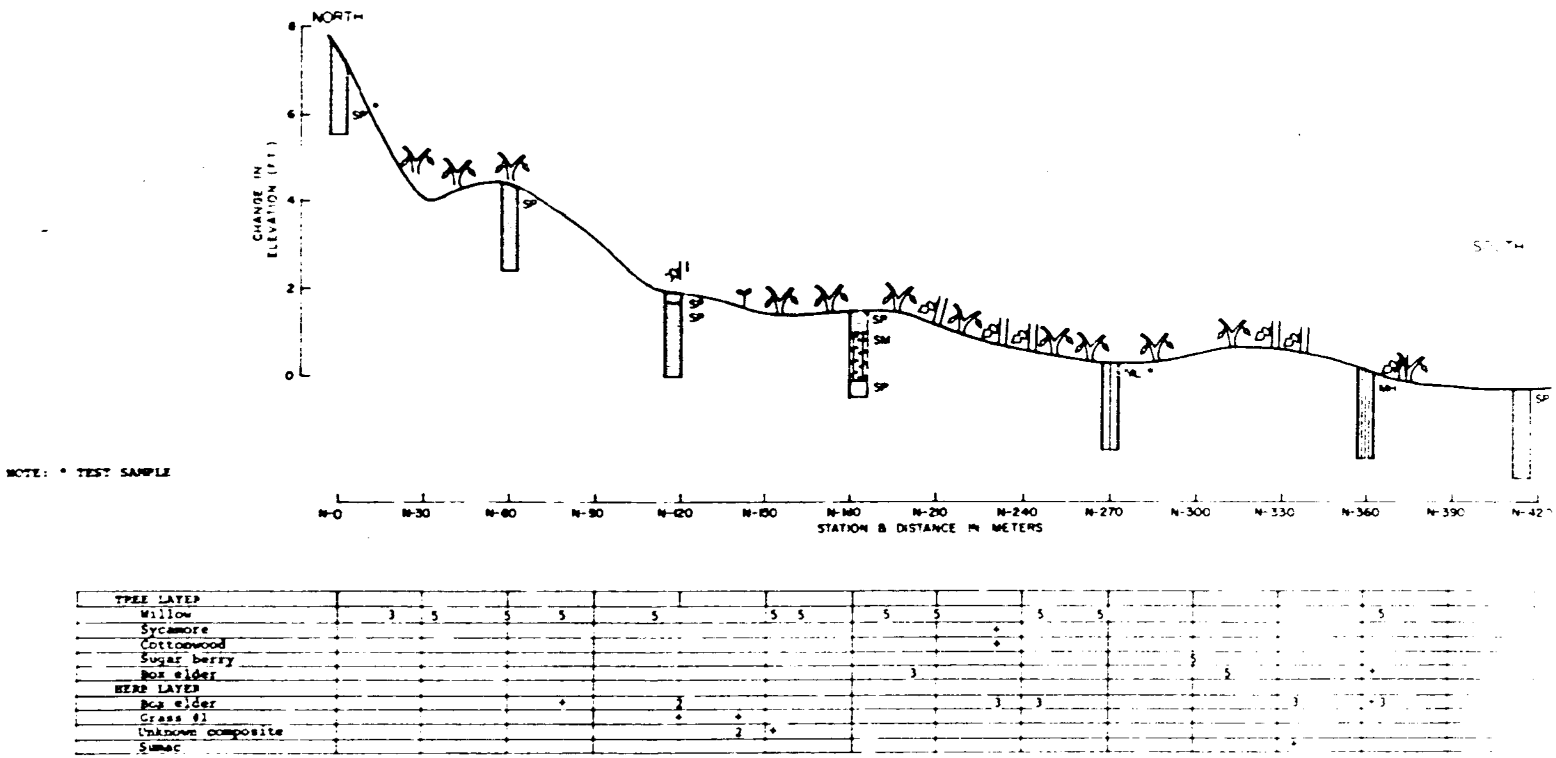
FIGURE 15



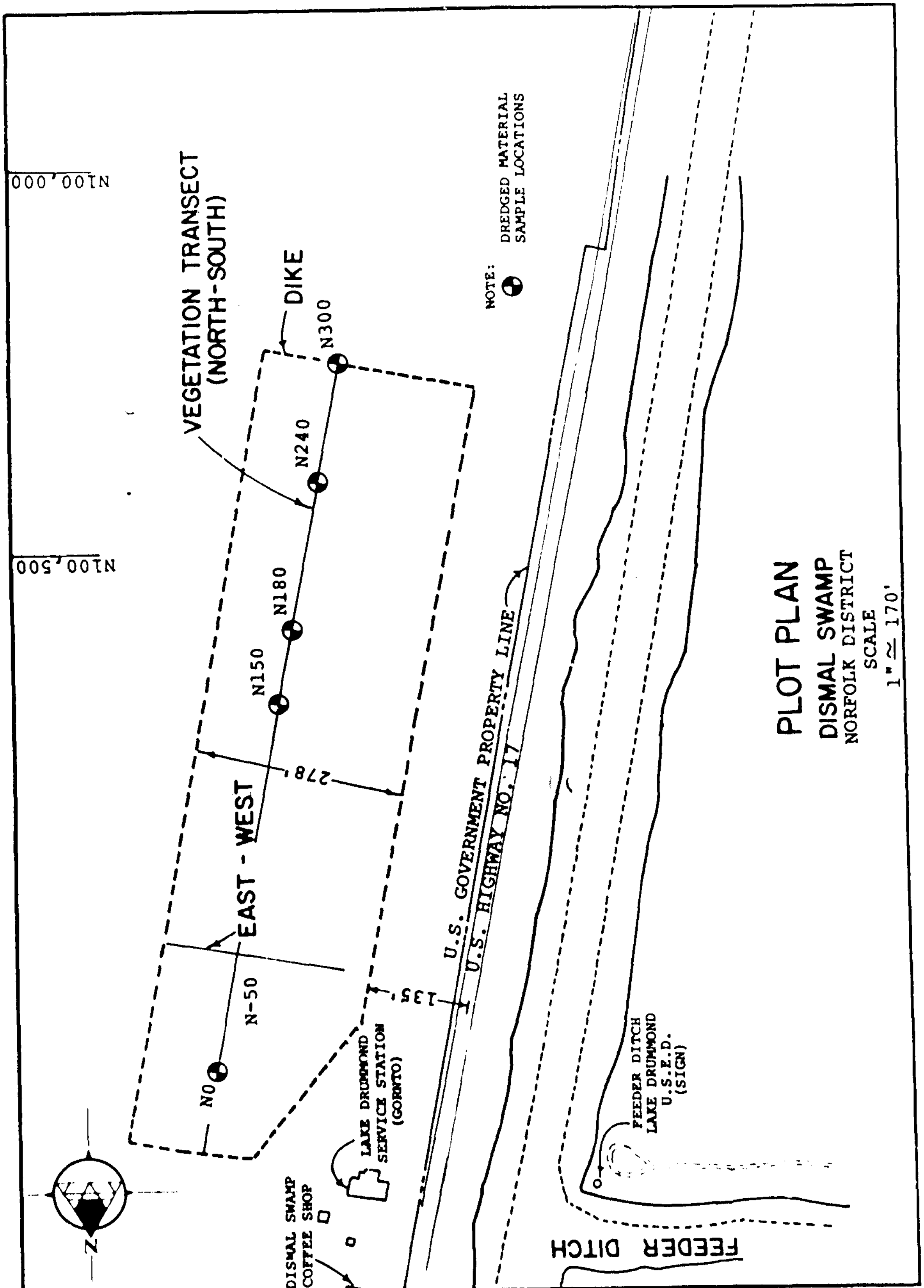
PLOT PLAN
TENNESSEE CHUTE
MEMPHIS DISTRICT

SCALE 1 24 000

FIGURE 16

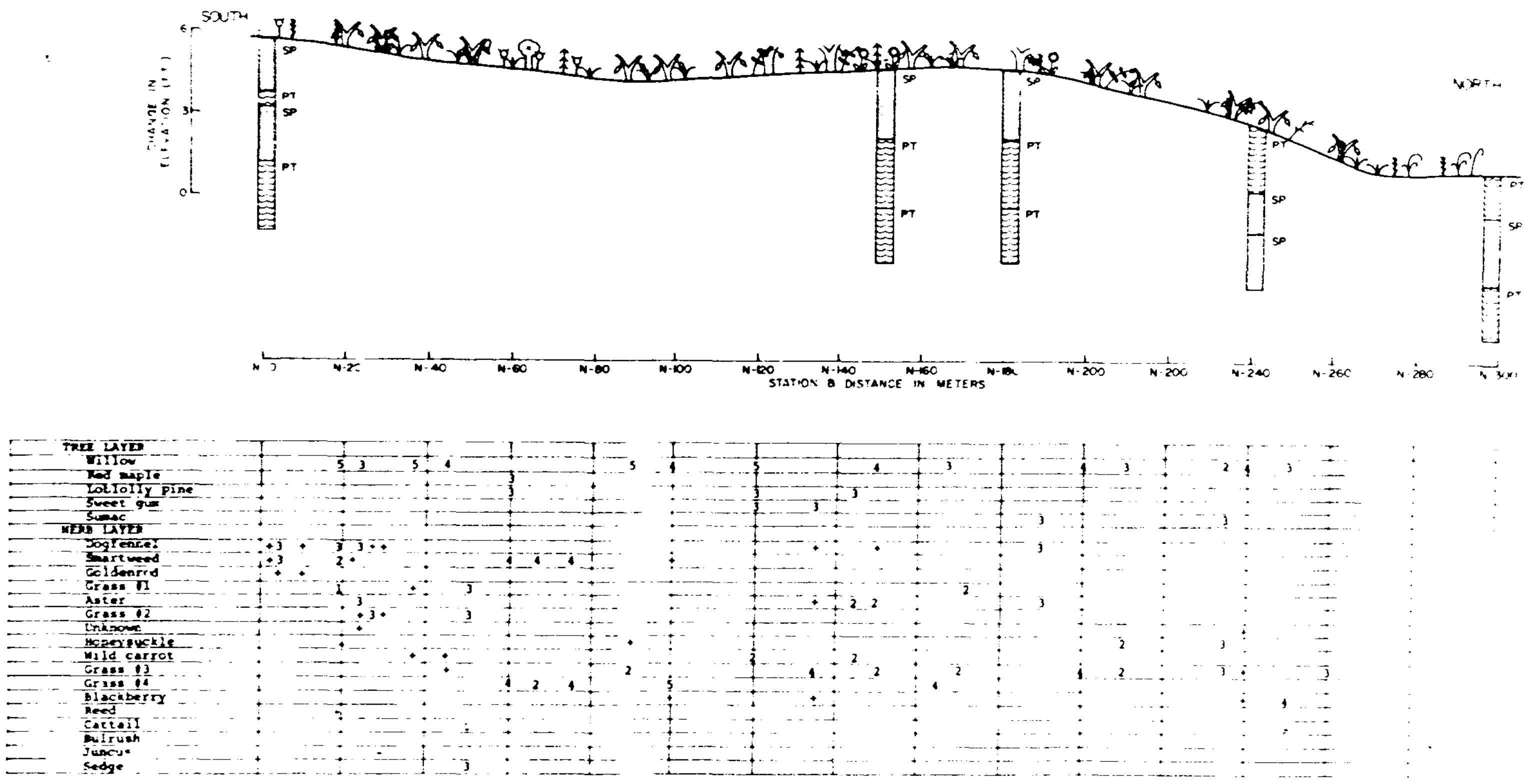


VEGETATION TRANSECT (NORTH-SOUTH)
TENNESSEE CHUTE

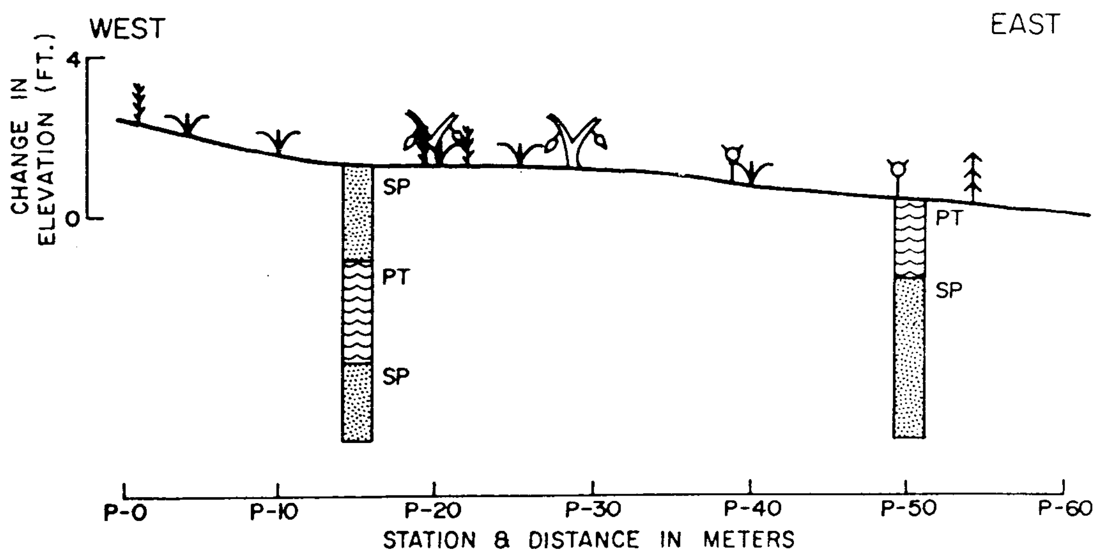


PLOT PLAN
DISMAL SWAMP
NORFOLK DISTRICT
SCALE
1" ≃ 170'
VEGETATION TRANSECT
(NORTH-SOUTH)
DIKE
EAST - WEST
N100,000
N100,500
N300
N240
N180
N150
N0
N-50
278'
135'
NOTE:
DREDGED MATERIAL
SAMPLE LOCATIONS
U.S. GOVERNMENT PROPERTY LINE
U.S. HIGHWAY NO. 17
LAKE DRUMMOND
SERVICE STATION
(GORNTO)
DISMAL SWAMP
COFFEE SHOP
FEEDER DITCH
LAKE DRUMMOND
U.S.E.D.
(SIGN)
FEEDER DITCH
N

FIGURE 18



VEGETATION TRANSECT (NORTH-SOUTH)
DISMAL SWAMP



TREE LAYER									
Willow				5	5		3		
Loblolly pine								3	
HERB LAYER									
Dogfennel	2	2		2	2		2		+
Smart weed	+				+	2	3		
Grass #1		3	2	2					+
Grass #2		3				2			
Grass #3	+		3		2	+			
Grass #4							2		
Bulrush		+							

VEGETATION TRANSECT (EAST-WEST)
DISMAL SWAMP

FIGURE 20

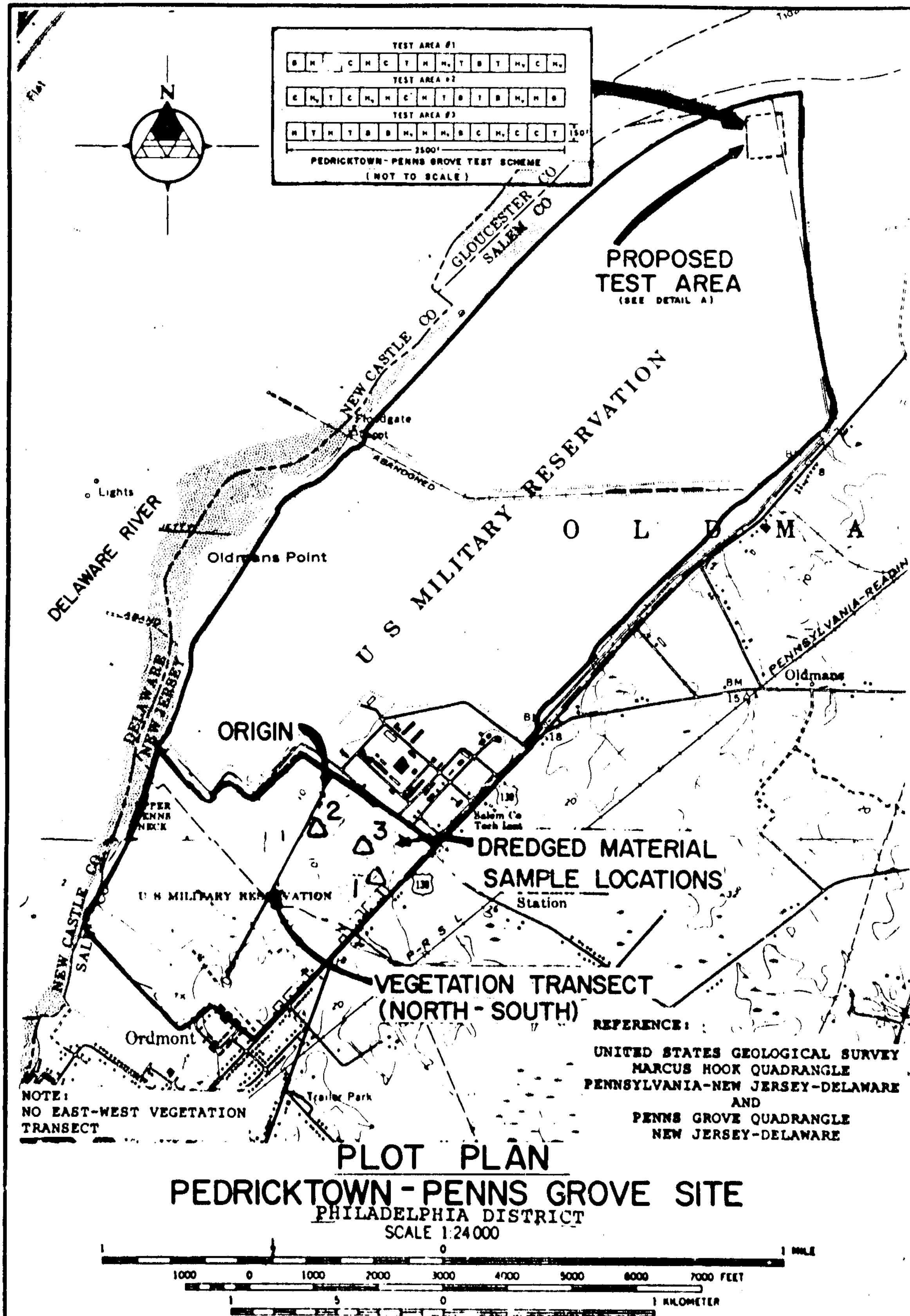
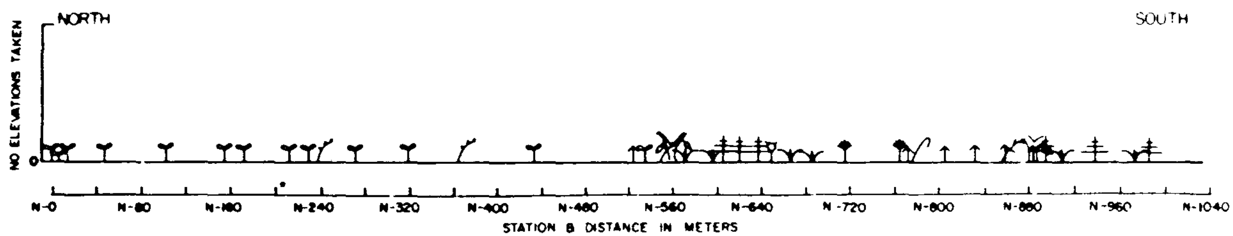

TEST AREA #1
TEST AREA #2
TEST AREA #3
PEDRICKTOWN-PENNS GROVE TEST SCHEME
(NOT TO SCALE)
N
PROPOSED
TEST AREA
(SEE DETAIL A)
GLOUCESTER CO
SALEM CO
NEW CASTLE CO
U S MILITARY RESERVATION
O L D M A
DELAWARE RIVER
Oldmans Point
Lights
DELAWARE
NEW JERSEY
ORIGIN
DREDGED MATERIAL
SAMPLE LOCATIONS
VEGETATION TRANSECT
(NORTH-SOUTH)
U S MILITARY RESERVATION
Ordmont
Oldmans
PENNSYLVANIA-READING
Station
Trailer Park
REFERENCE:
UNITED STATES GEOLOGICAL SURVEY
MARCUS HOOK QUADRANGLE
PENNSYLVANIA-NEW JERSEY-DELAWARE
AND
PENNS GROVE QUADRANGLE
NEW JERSEY-DELAWARE
NOTE:
NO EAST-WEST VEGETATION
TRANSECT
PLOT PLAN
PEDRICKTOWN-PENNS GROVE SITE
PHILADELPHIA DISTRICT
SCALE 1:24000
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER

FIGURE 21

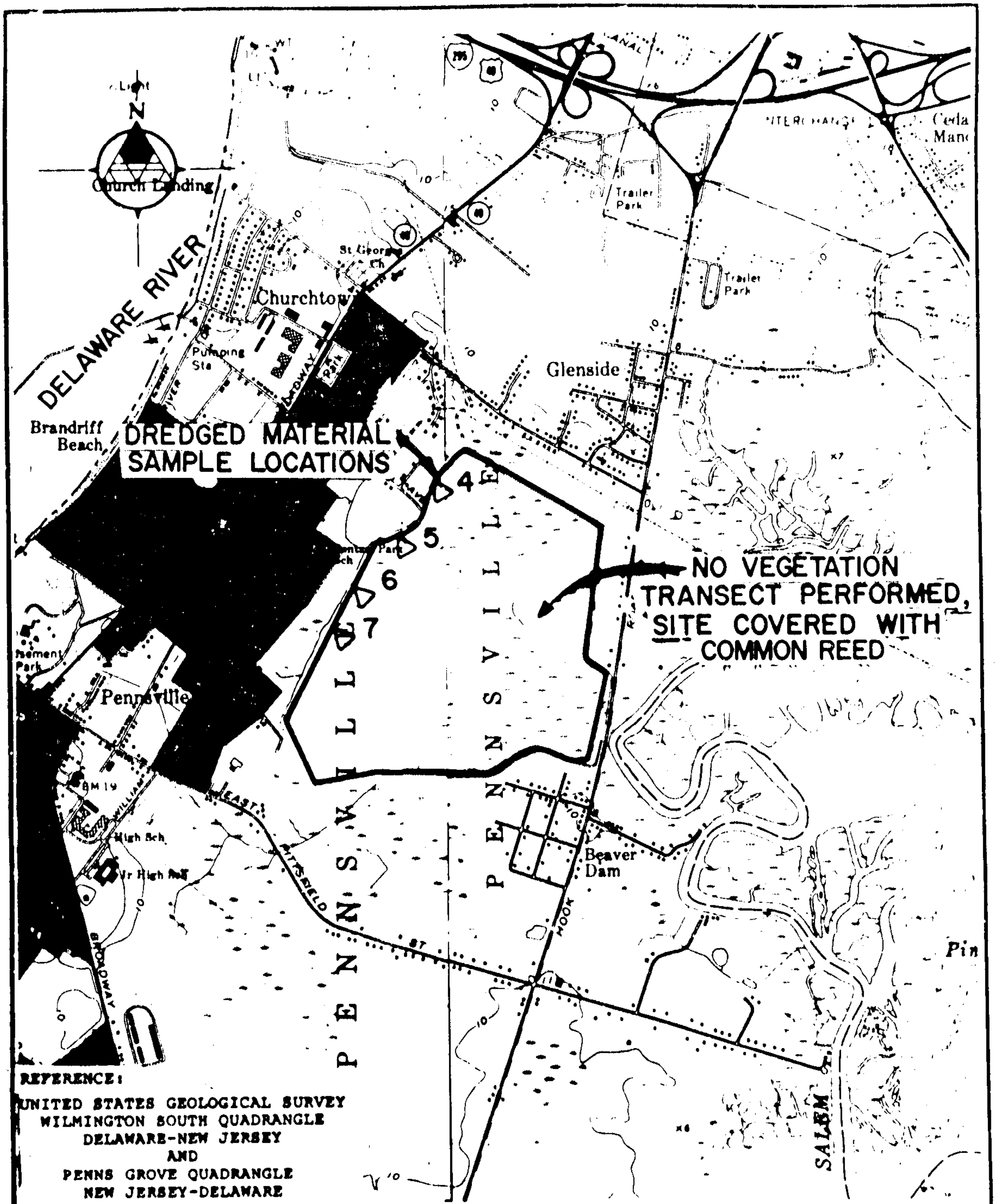


NOTE:
NO DREDGED MATERIAL PLACED ON SITE
AS OF DECEMBER 13, 1973
* TEST SAMPLE INDICATES GRAY FINE SAND

TREE LAYER													
Unknown							4						
Willow							4						
Arrow-wood										3 5	5		
Ash												4	
HERB LAYER													
Composite #1	514 5	5	15 5	4 5	5 4	5	4						
Smartweed	2												
Aster			+ 2										
Sumac			+	+									
Goldenrod			+	4	5	+	4			+ +		+	
Unknown #1					+		5						2
Arrow-wood										3		2	
Blackberry							+			+	4		
Honeysuckle							+				+		
Unknown #2								4 5 3	2 4 +	2		2 4	
Cattail								+ + +					
Grass #1								5	1 5 5			4 2	5
Tearthumb								3 +	2 3	+			
Grass #2								5					
Reed								+	+	5 3			
Juncus										3			

VEGETATION TRANSECT (NORTH-SOUTH)
PEDRICKTOWN-PENNS GROVE

FIGURE 22



PLOT PLAN
PENNS NECK
PHILADELPHIA DISTRICT

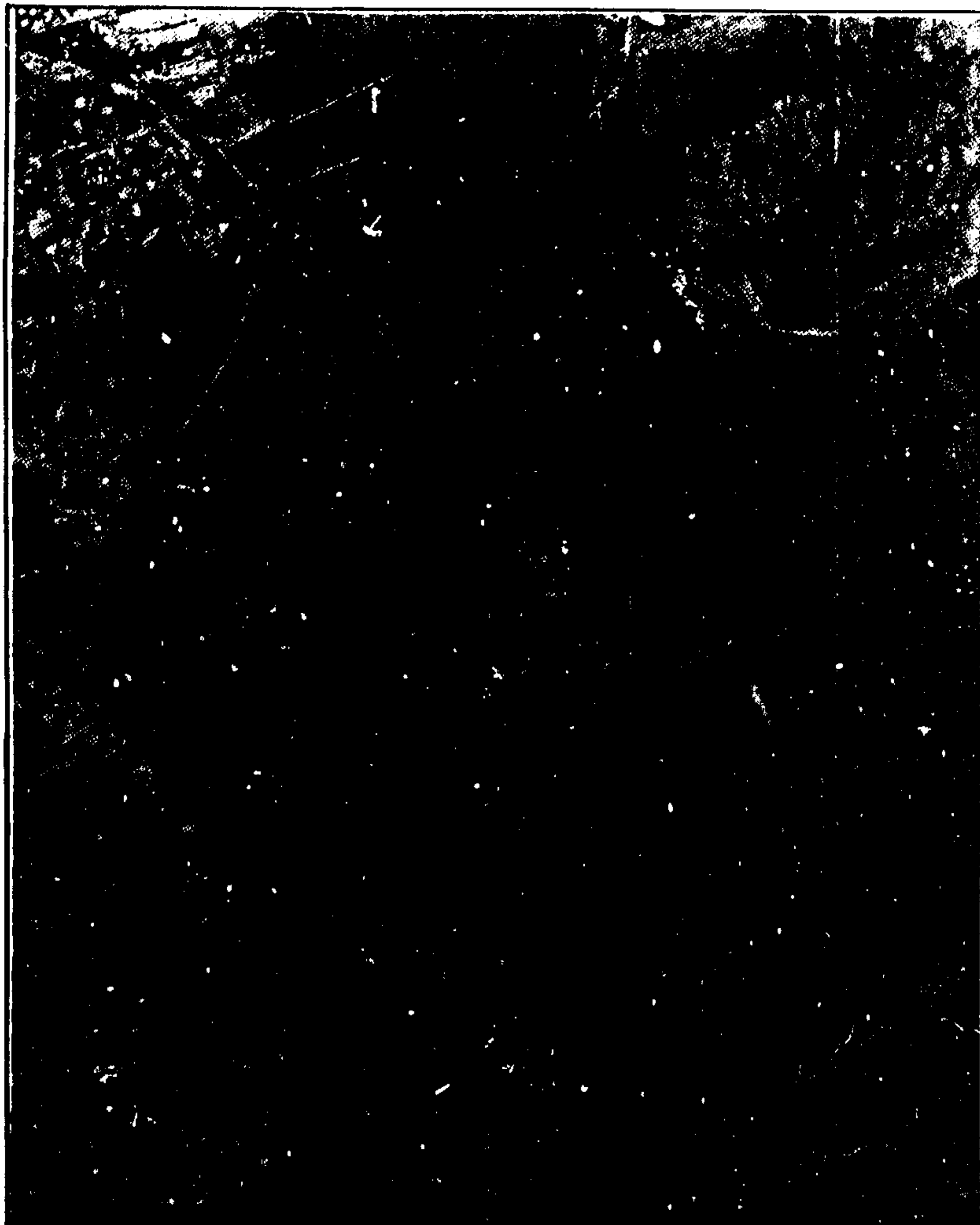
SCALE 1:24 000

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 KILOMETER

FIGURE 23



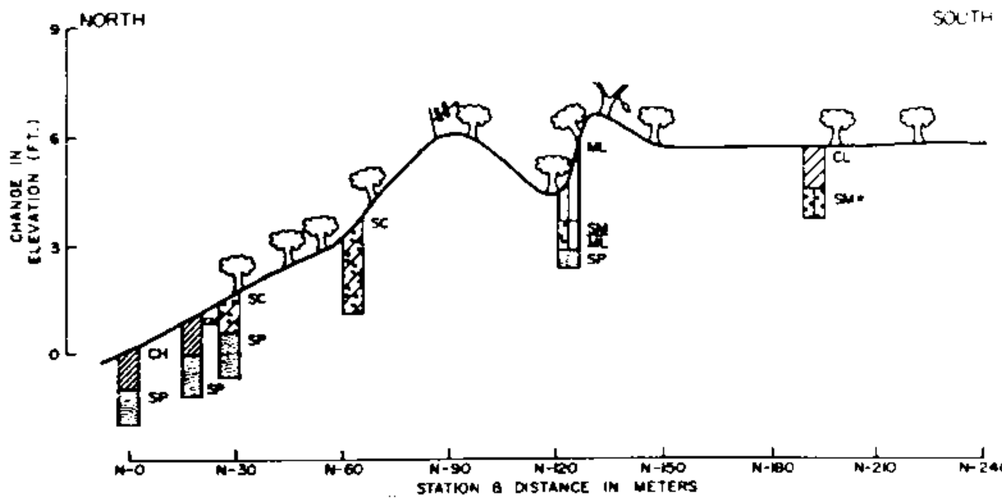
FLOWN: 3-1-73
SCALE: 1:6000

PLOT PLAN
DRUM ISLAND
CHARLESTON DISTRICT

FEET

1500 0 1500 3000

FIGURE 24



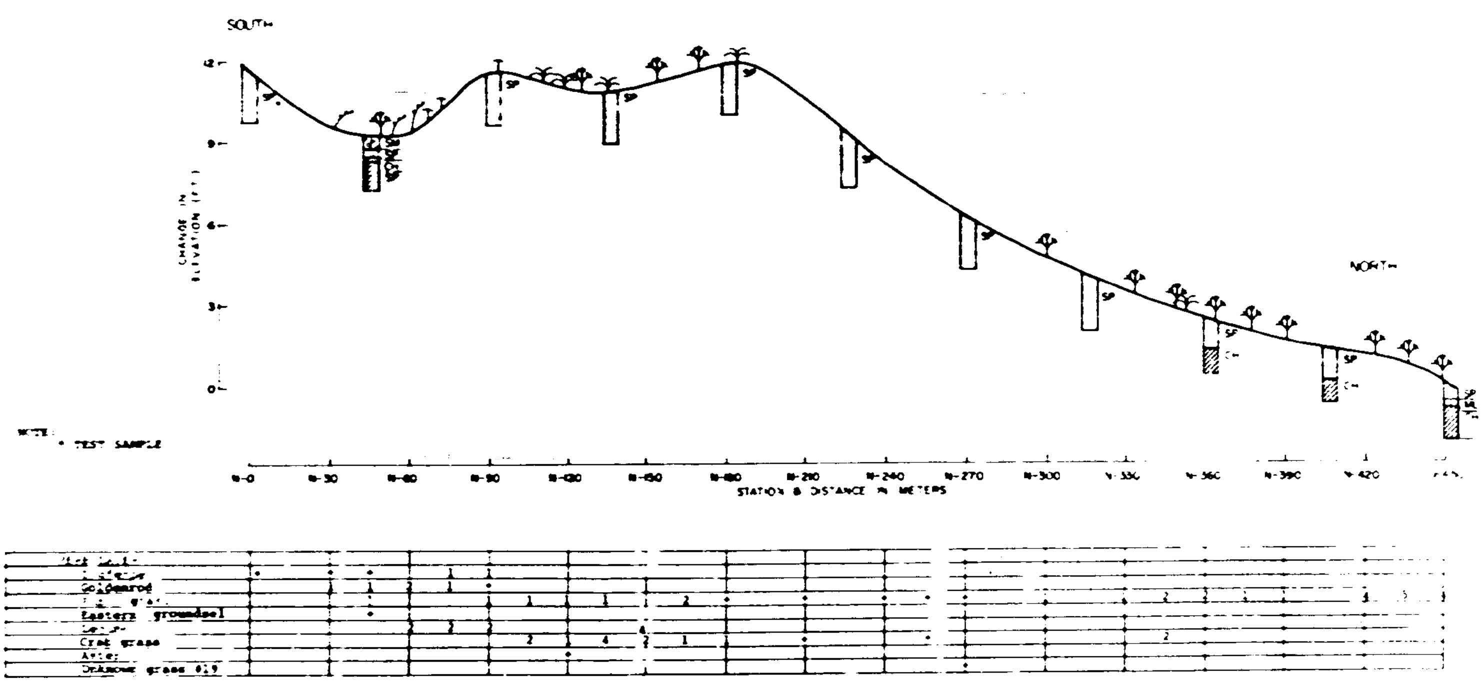
NOTE:
* TEST SAMPLE

TREES								
Eastern groundsel	4							1
Red mulberry	5	5	4	2	4	3	4	5
Sugarberry						1		
HERBS & SHRUBS								
Unknown grass #1	3							
Red mulberry	+ 1	2			4			
Eastern groundsel	3 5							
Sugarberry	+				2 3			
Common elder				1				

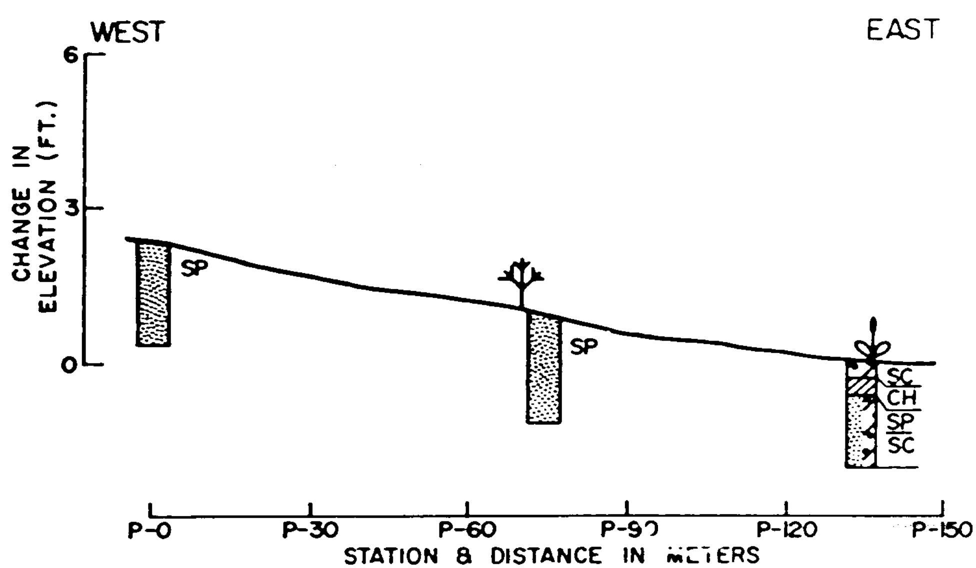
VEGETATION TRANSECT (NORTH-SOUTH)
DRUM ISLAND

*REDUCED COPY
ORIGINAL-11" X 17"

FIGURE 26



VEGETATION TRANSECT (NORTH-SOUTH)
NO. 2 SAVANNAH

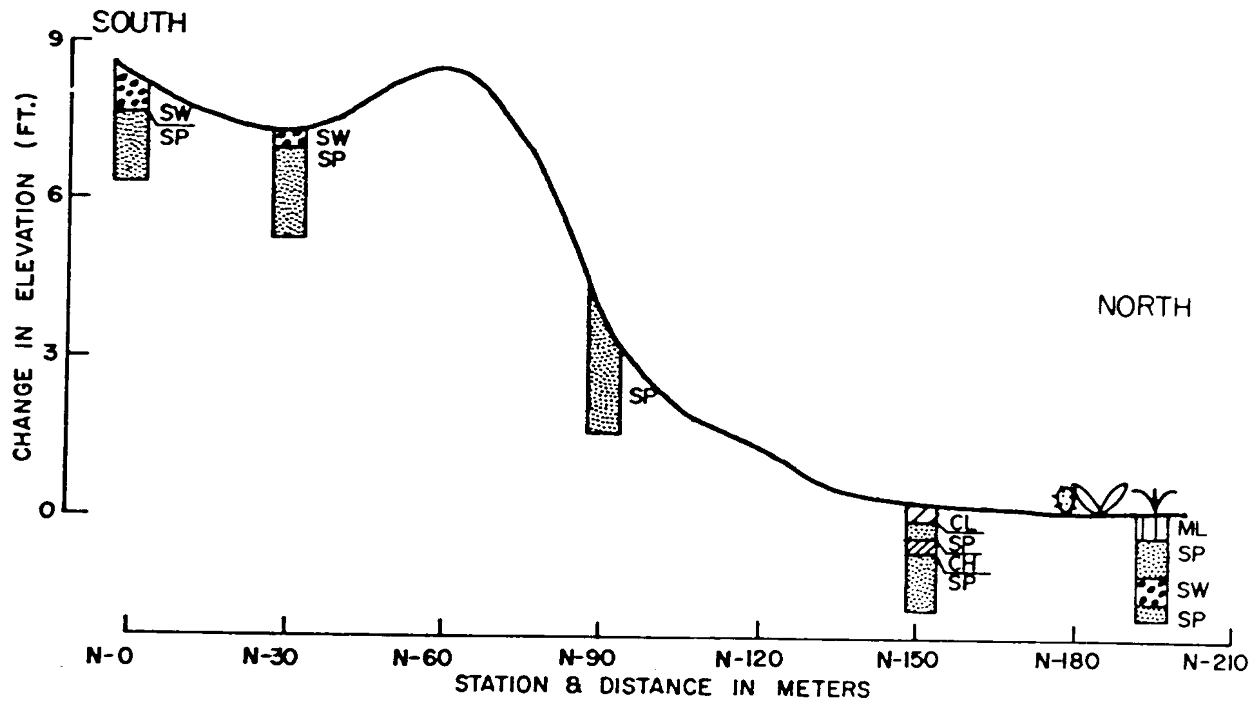


HERB LAYER					
Panic grass			1		
Cattail					4
Unknown					3

VEGETATION TRANSECT (EAST-WEST)
NO. 2 SAVANNAH

FIGURE 28

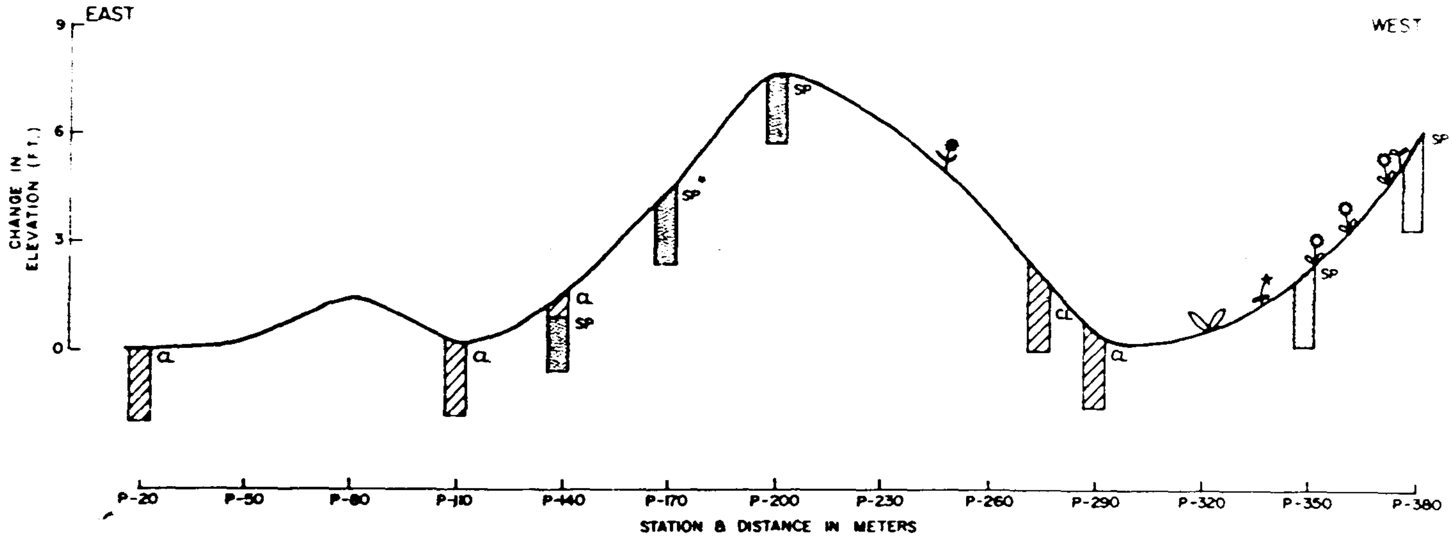
FIGURE 29



HERB LAYER							
Unknown composite					+		
Spiny-leaved sow thistle					+		
Cactus						1	
Yucca						1	
Unknown grass #10							2

VEGETATION TRANSECT (NORTH-SOUTH)
OYSTER BED ISLAND

FIGURE 30



NOTE:
* TEST SAMPLE

HERB LAYER												
Yucca					+						1	
Spiny-leaved sow thistle					+							
Golden aster								+ 1				
Buffalo burr											2	
Aster												3 3 1
Unknown composite												+ + 1
Sea ox-eye												+
Grasses (mixed)												+

VEGETATION TRANSECT (EAST-WEST)
OYSTER BED ISLAND

FIGURE 31

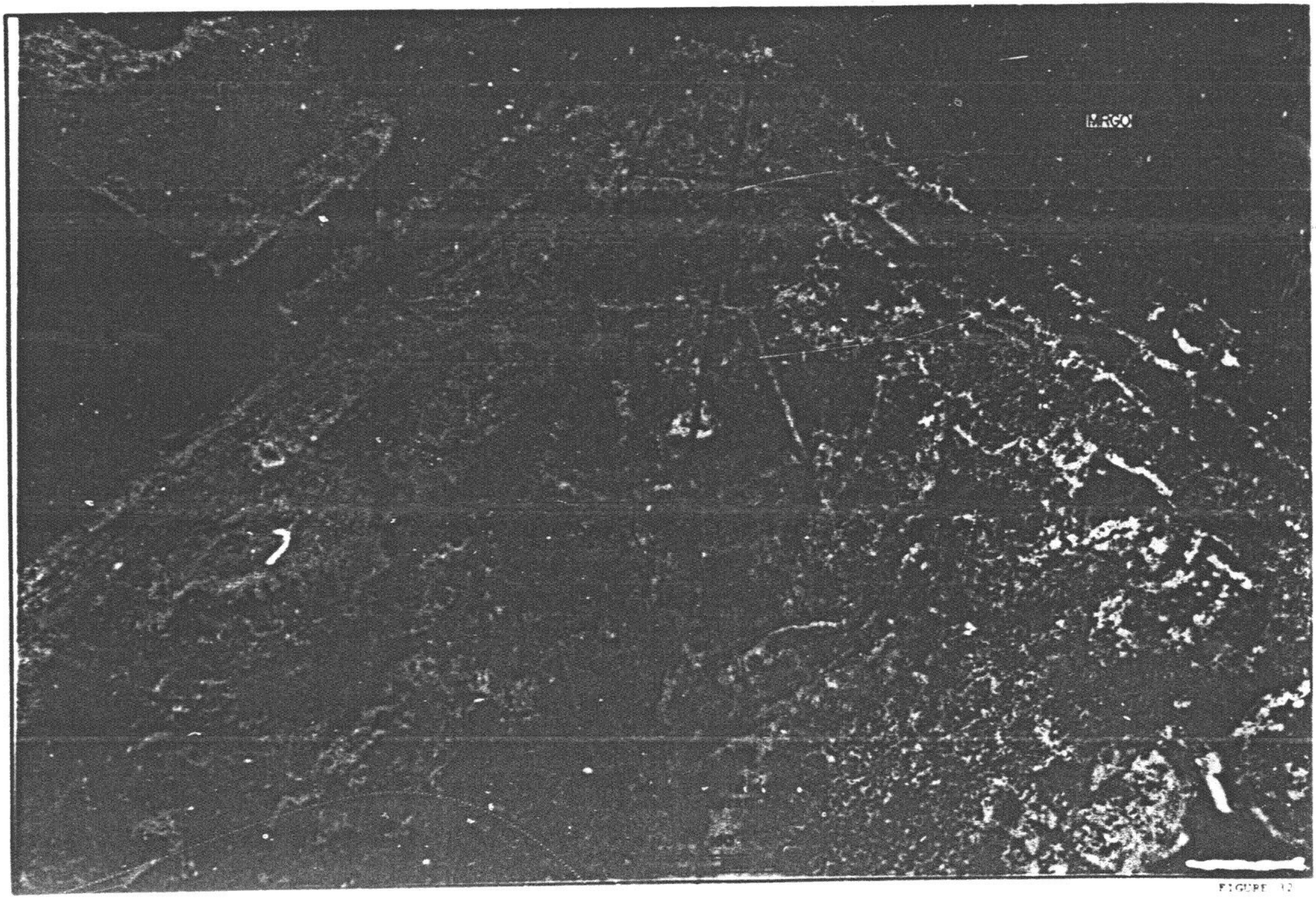
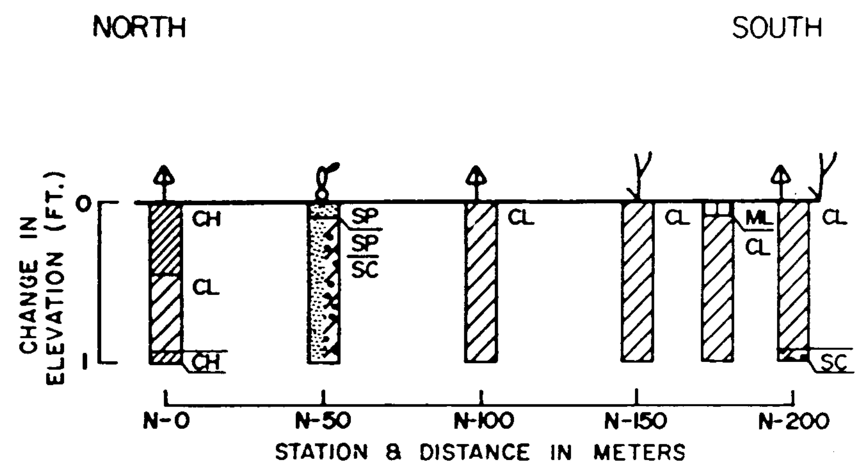


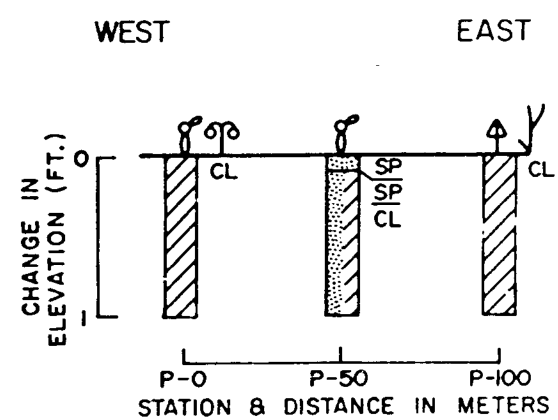
FIGURE 12



HERB LAYER					
Eastern groundsel	2				
Marsh elder	5		3	2	4
Grasswort		4			
Salt grass			2	5	4
Saltwort			+		

VEGETATION TRANSECT (NORTH-SOUTH)
STATION 23.6
MRGO

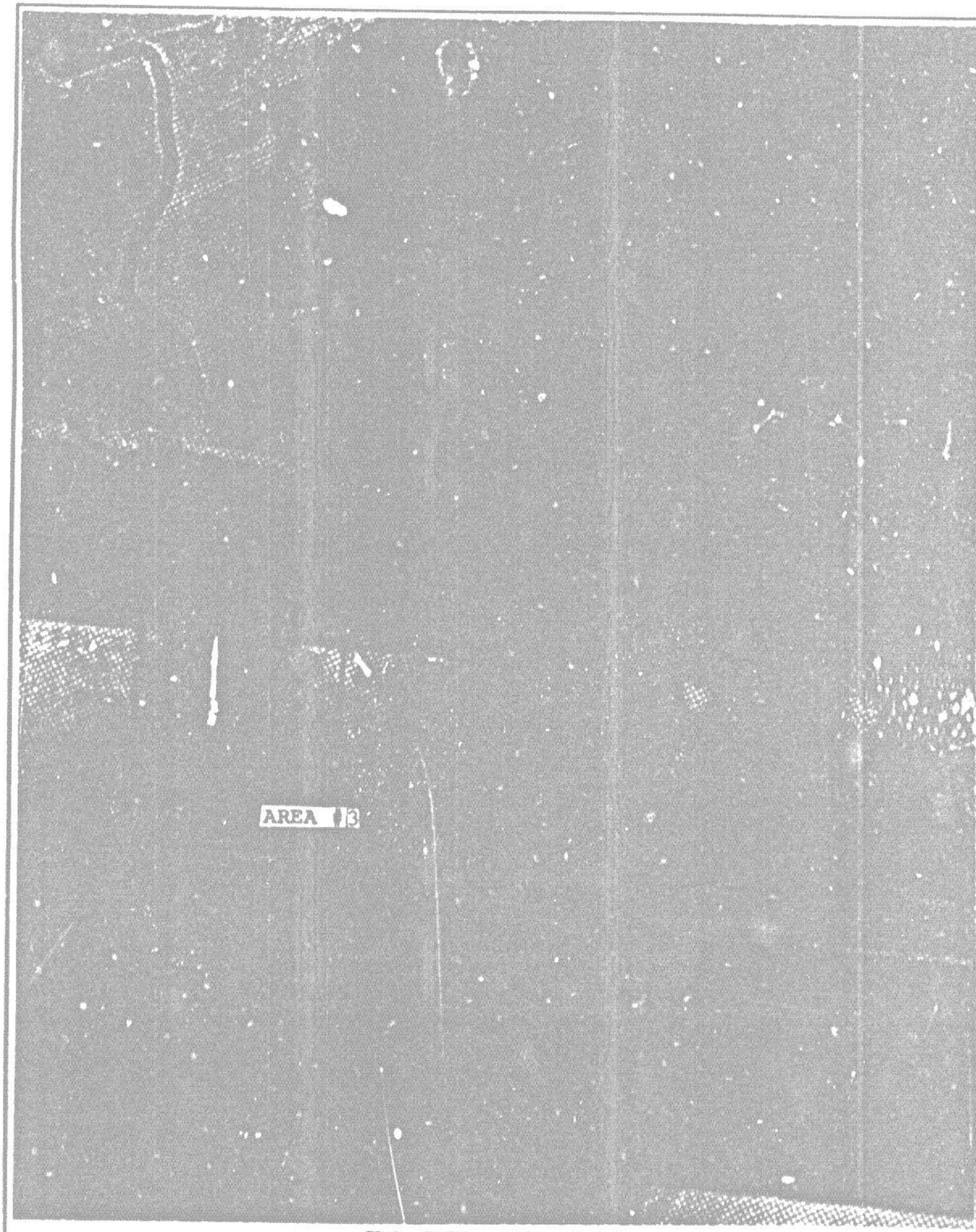
FIGURE 33



HERB LAYER	P-0	P-50	P-100
Marsh elder			4
Glasswort	+	4	
Salt grass			5
Saltwort	+		+

VEGETATION TRANSECT (EAST-WEST)
STATION 23.6
MRGO

FIGURE 34



PLOT PLAN

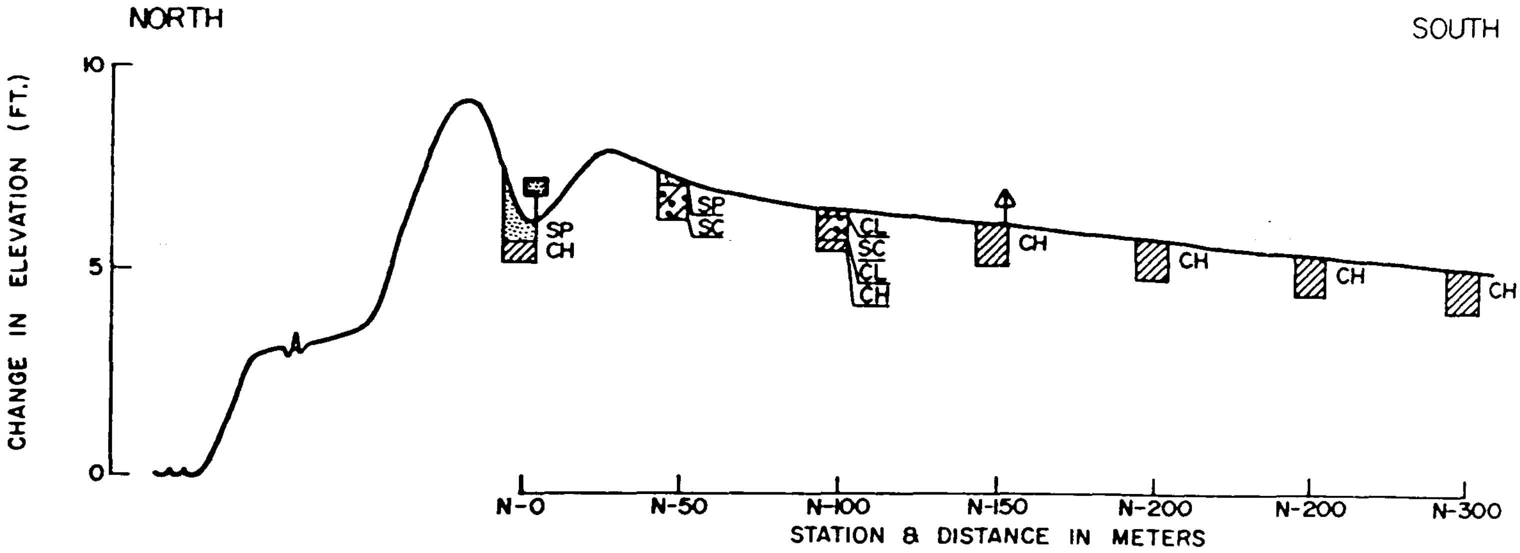
STATION 41 - MRGO

NEW ORLEANS DISTRICT

FEET

1600 0 1600 3200

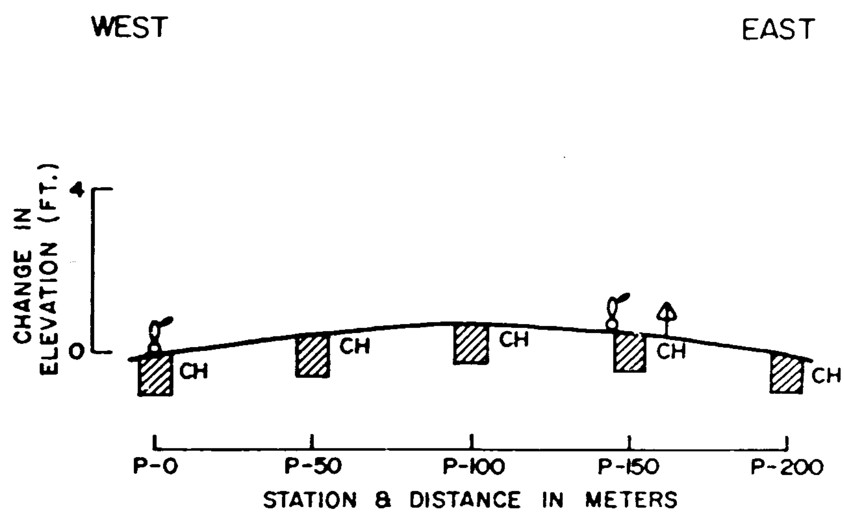
FIGURE 35



HERB LAYER							
Coco	4						
Marsh elder		2		+			

VEGETATION TRANSECT (NORTH-SOUTH)
STATION 41 MRGO

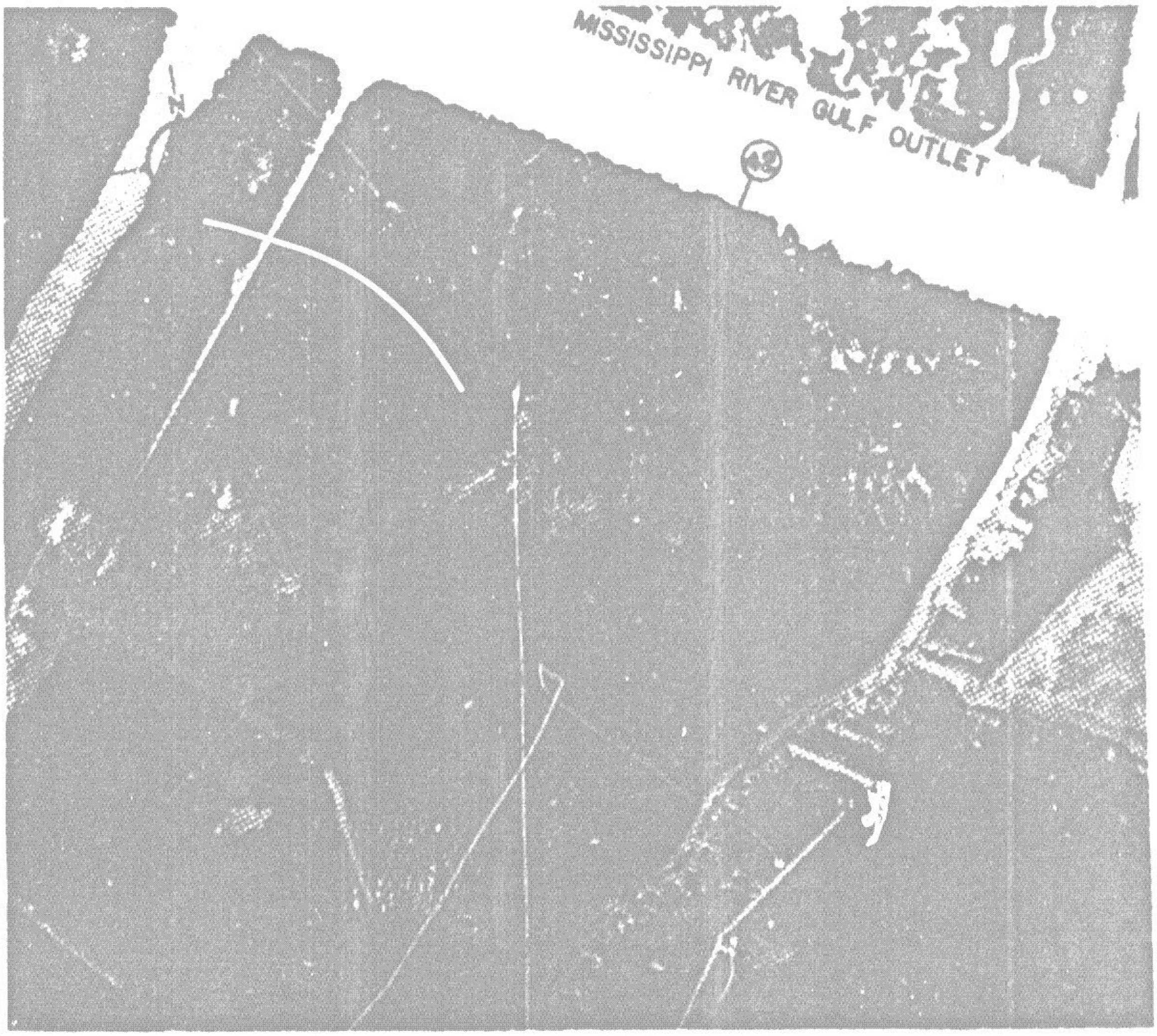
FIGURE 36



HERB LAYER					
Marsh elder				+	
Glasswort	+			+	
Saltwort				+	

VEGETATION TRANSECT (EAST-WEST)
STATION 41
MRGO

FIGURE 37



REFERENCE:
THIS PHOTOGRAPH IS A PART OF
PHOTO. ROLL. BC-73-10, PHOTO NO. 234
FLOWN: 15, MAY, 1973
SCALE: 1:36,000
BONNET CARRE FLOODWAY & LAKE
PONTCHARTRAIN & VICINITY

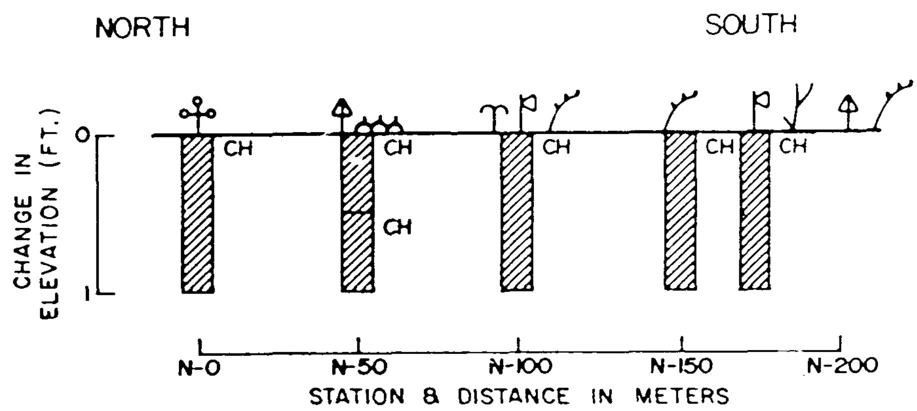
PLOT PLAN
STATION 42-MRGO

NEW ORLEANS DISTRICT

FEET

750 0 750 1500

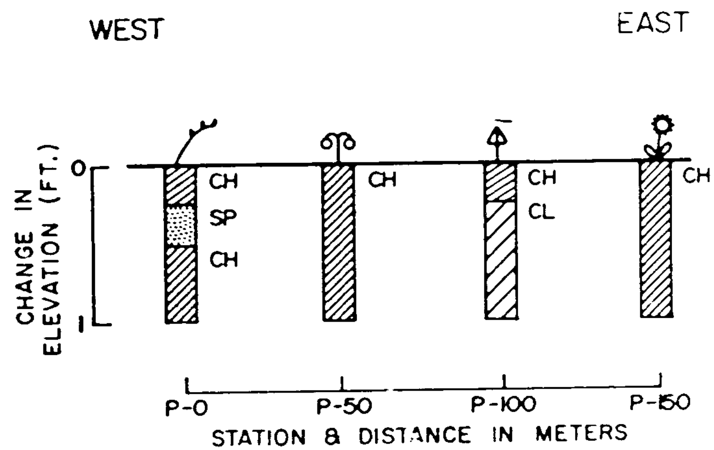
FIGURE 38



HERB LAYER						
Beard grass			2			
Coco		+			4	
Eastern groundsel			2	1	5	
Marsh elder		4				2
Smooth cord grass		4				
Seaside salt grass					5	
Saltwort		+				
Seaside goldenrod	+		2	3		2
Solanum	5					

VEGETATION TRANSECT (NORTH-SOUTH)
STATION 42
MRGO

FIGURE 39



HERB LAYER	P-0	P-50	P-100	P-150
Eastern groundsel	+			
Goldenrod		+		
Marsh elder			4	
Glasswort	+			
Ragwort		+		
Salt grass			+	
Aster				5
Saltwort		4		
Seaside goldenrod	3		3	

VEGETATION TRANSECT (EAST-WEST)
STATION 42
MRGO

FIGURE 40

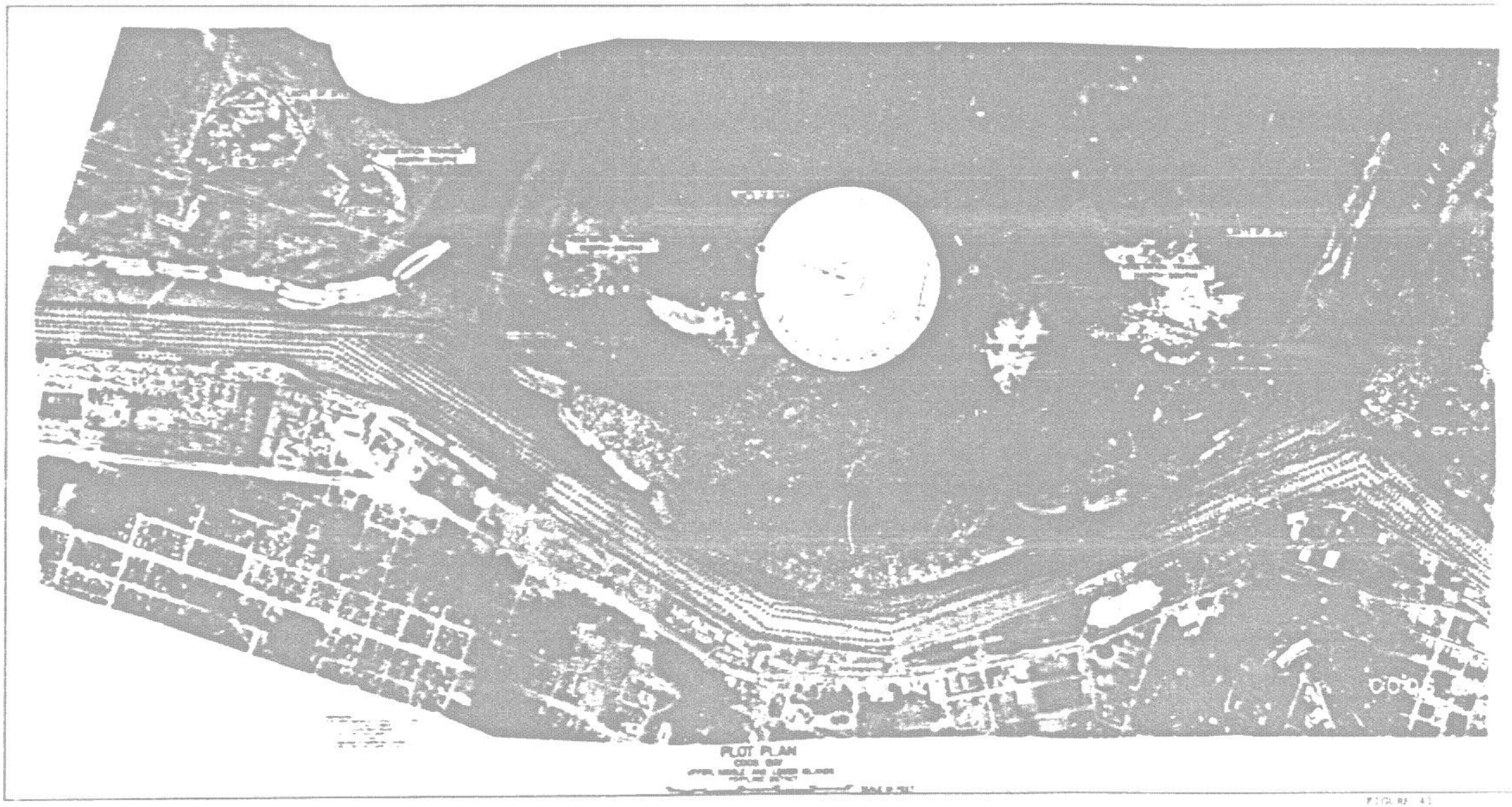


FIGURE 41

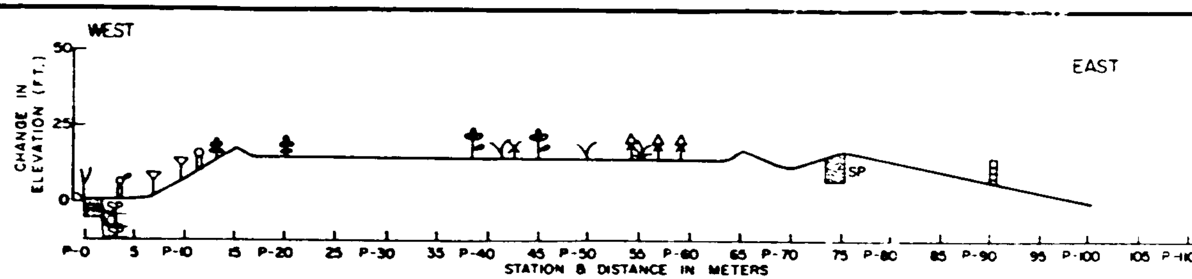
sparrows, mourning doves, and an American kestrel in lowlying areas, there was a large population of semipalmated and black-bellied plovers.

43. The most noted aspect of the faunal distribution on Drum Island was a well-developed heron colony on the northwest confinement. Outside the dike, marsh rabbits were plentiful, and there were also populations of fiddler crabs, great blue herons, Louisiana herons, and marsh hawks. Inside the dike area was an abundant population of ruby-crowned kinglets, cardinals, song sparrows, red-winged blackbirds, common and boat-tailed grackles, shore birds, and dark-eyed juncos; also present were clapper rails and a palm warbler.

44. Constraints. C.E. personnel were questioned about legal or economic constraints in the disposal of dredged material but few were cited. Typically the constraints related to restrictions imposed by the U. S. Department of the Interior or the expiration of land easements. The EPA criteria for nonpolluted dredged material were not mentioned.

Summary of Laboratory Tests

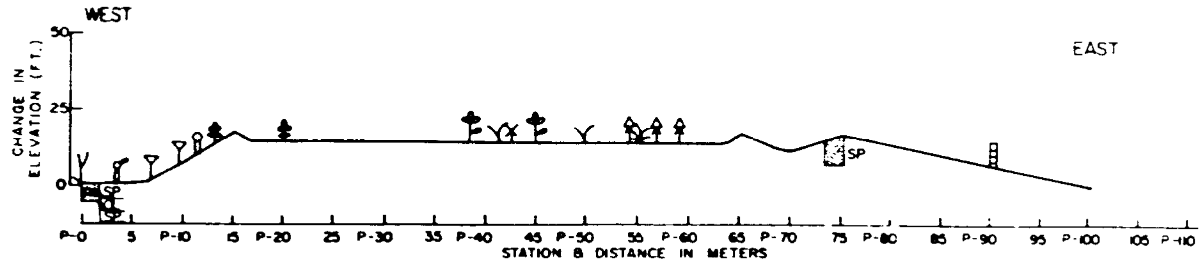
45. The dredged material grain-size distribution test results are shown in Figures 48 through 53. The tested material varied in gradation from clayey silts to gravelly sands. These sediment types are considered typical for maintenance-type dredged material (Boyd et al. 1972, Cecale 1969, Krizek et al. 1973, Garbe and Jeno 1968, Garbe 1974, Cooper 1972).



HERB LAYER	P-0	P-10	P-20	P-30	P-40	P-50	P-60	P-70	P-80	P-90	P-100
Seashore salt grass	2				+	+ +					
English plantain	+ +										
Glasswort	+ 5										
Early hair grass	1					1 1					
Beach grass	3 2										
Yellow sandverbena	2 2										
Yarrow		1									
Dock	1	+									
Spotted cat's-ear		+ +									
Red clover		2			+ +	+ +	+		+		
Spiny-leaved sow thistle		1 +									
Canada fleabane		+					+				
Unknown		+							+		
White sweet clover			3								
Italian rye grass			+		2	2					
Sedge				+		2 3 2					
White clover				2	2						
Gumweed					2						
Velvet grass					+ +	+ +	+		+		
Coast alkali grass						2					
Common groundsel							+				
Sea rocket							+	+		2	

VEGETATION TRANSECT (EAST-WEST)
COOS BAY-LOWER ISLAND

FIGURE 47

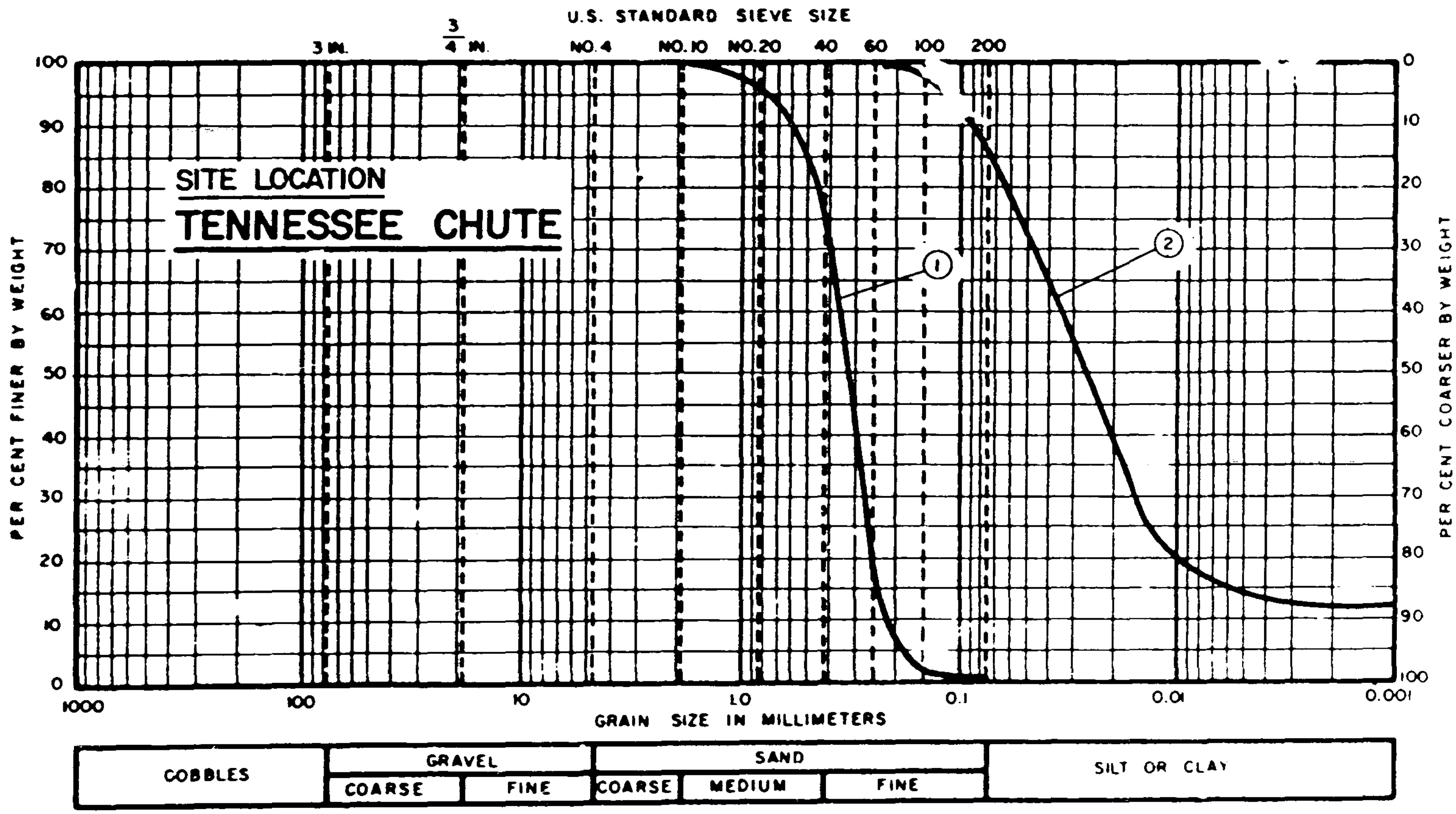


HERB LAYER											
Seashore salt grass	2				+ +	+					
English plantain	+ +										
Glasswort	+ 5										
Early hair grass	1					1 1					
Beach grass	3 2										
Yellow sandverbena	2 2										
Yarrow		1									
Dock	1	+									
Spotted cat's-ear		+ +									
Red clover		2			+ +	+ +	+		+		
Spiny-leaved sow thistle		1 +									
Canada fleabane		+					+				
Unknown		+							+		
White sweet clover			3								
Italian rye grass			+		2 2						
Sedge				+		2 3 2					
White clover				2	2						
Gumweed					2						
Velvet grass					+ + +	+	+		+		
Coast alkali grass						2					
Common groundsel							+				
Sea rocket							+ +		2		

VEGETATION TRANSECT (EAST-WEST)
COOS BAY - LOWER ISLAND

FIGURE 47

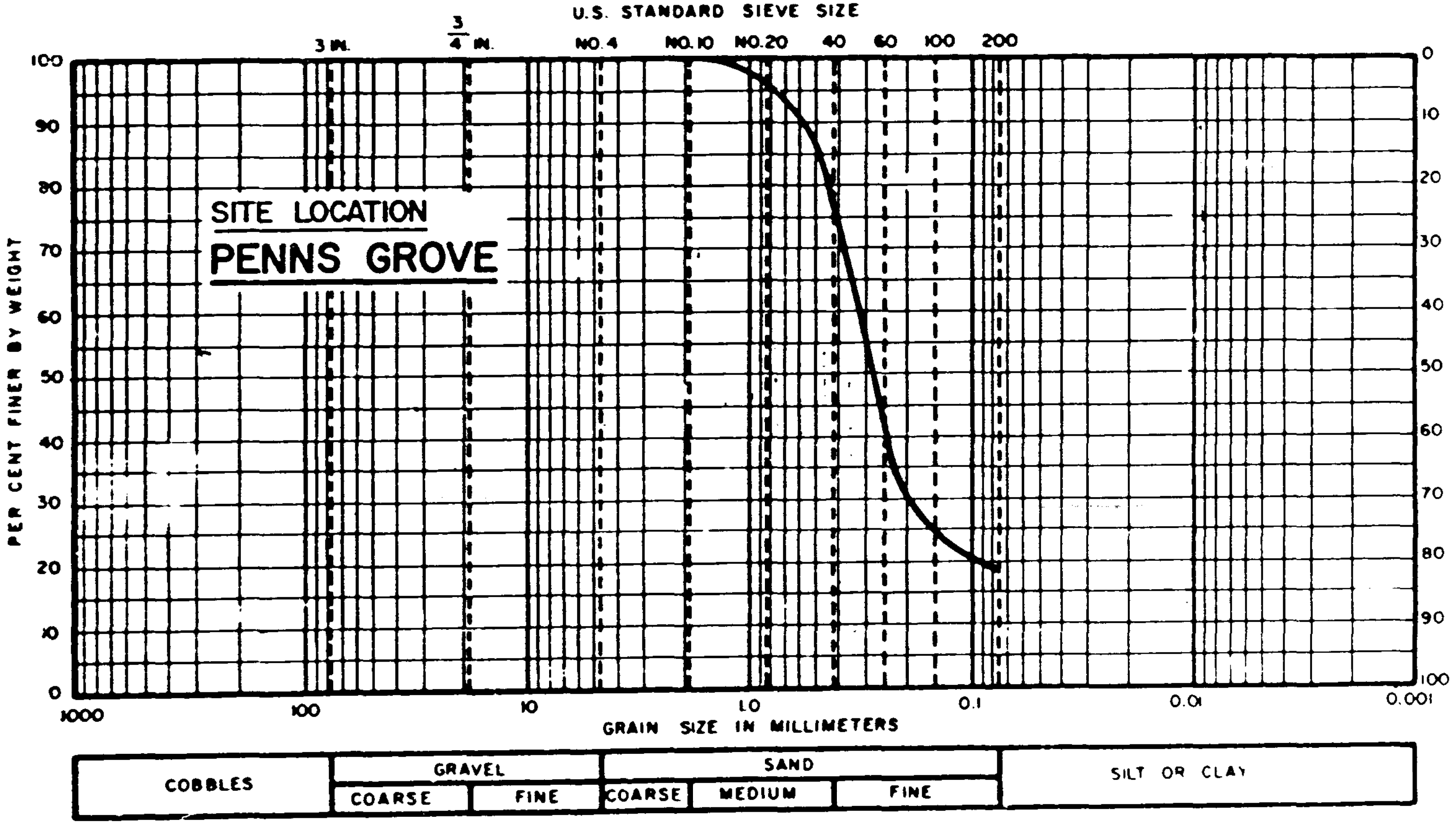
BORING	DEPTH	ELEV.	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SYMBOL	SOIL CLASSIFICATION	KEY
N - 0	1'-0"		1			SP	LIGHT BROWN FINE TO MEDIUM SAND	1
N - 270	1'-0"		2			ML	DARK GRAY CLAYEY SANDY SILT	2



GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

FIGURE 48

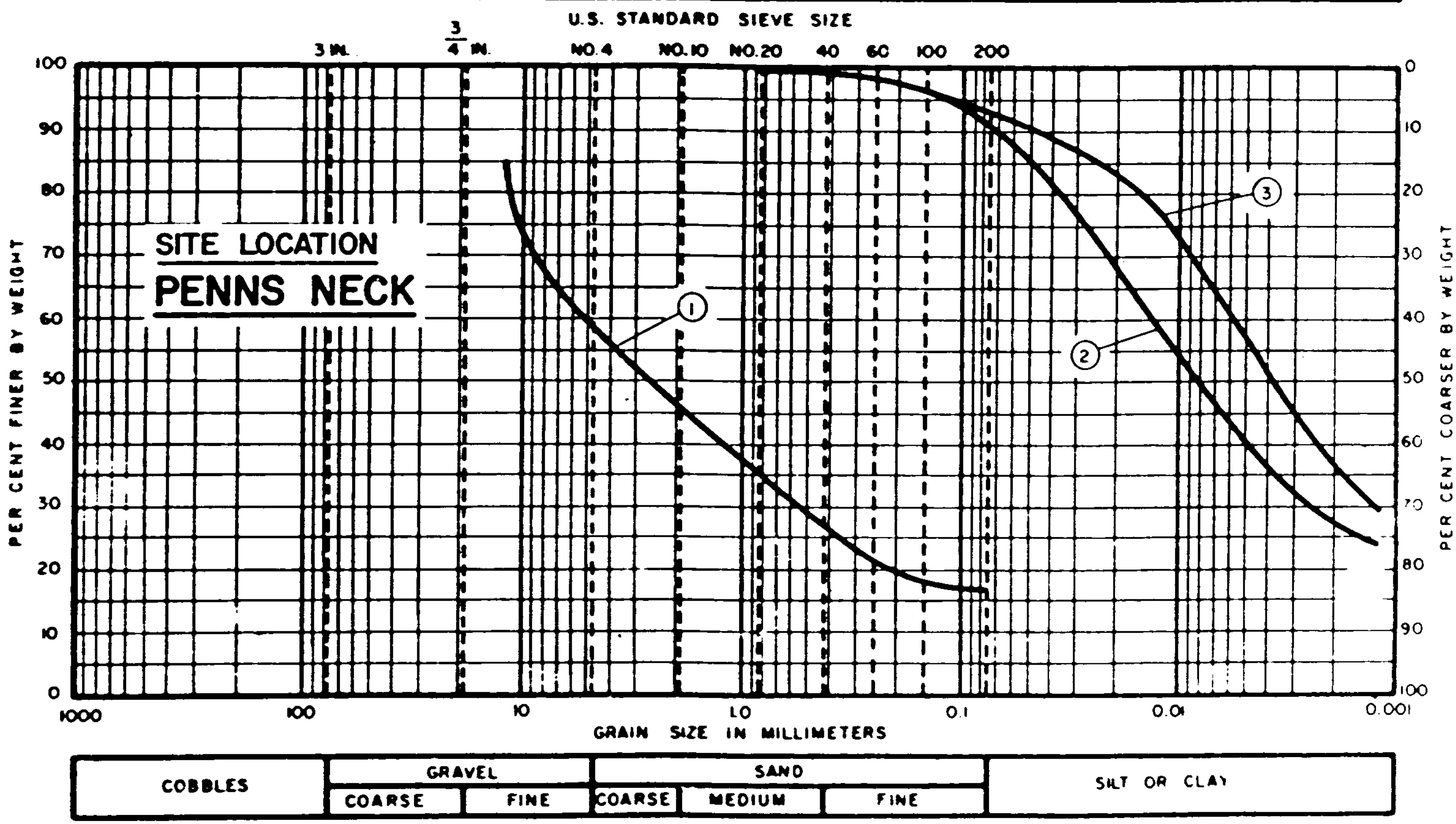
BORING	DEPTH	ELEV.	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SYMBOL	SOIL CLASSIFICATION	KEY
	6"		2			SM	GRAY FINE SAND	



GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

FIGURE 49

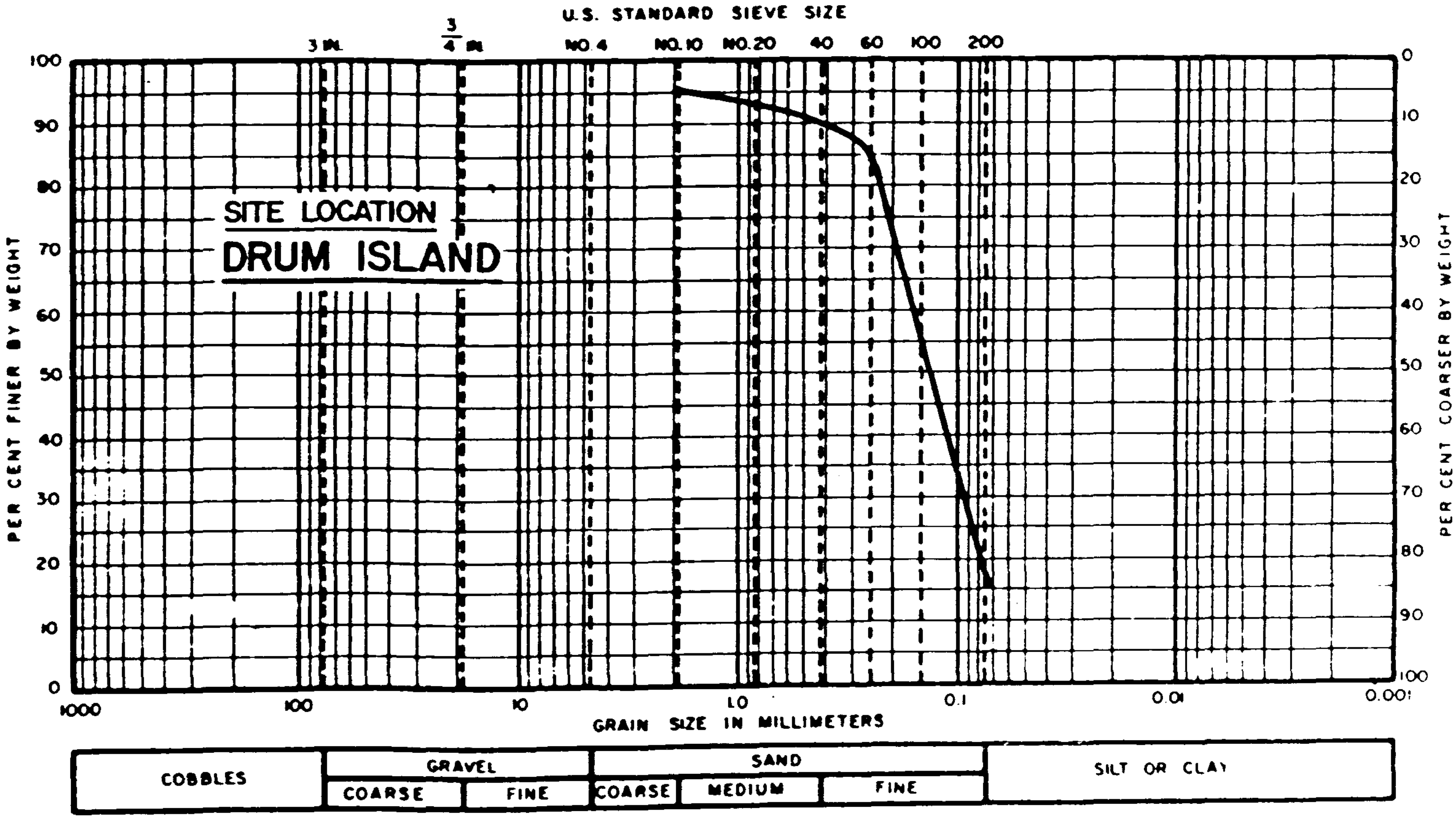
BORING	DEPTH	ELEV.	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SYMBOL	SOIL CLASSIFICATION	KEY
	6"		4			SP	GRAY GRAVELLY FINE TO COARSE SAND	1
	6"		5			CL	GRAY CLAYEY SILT, TRACE OF SAND	2
	6"		7			CL	GRAY CLAYEY SILT, TRACE OF SAND	3



GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

FIGURE 50

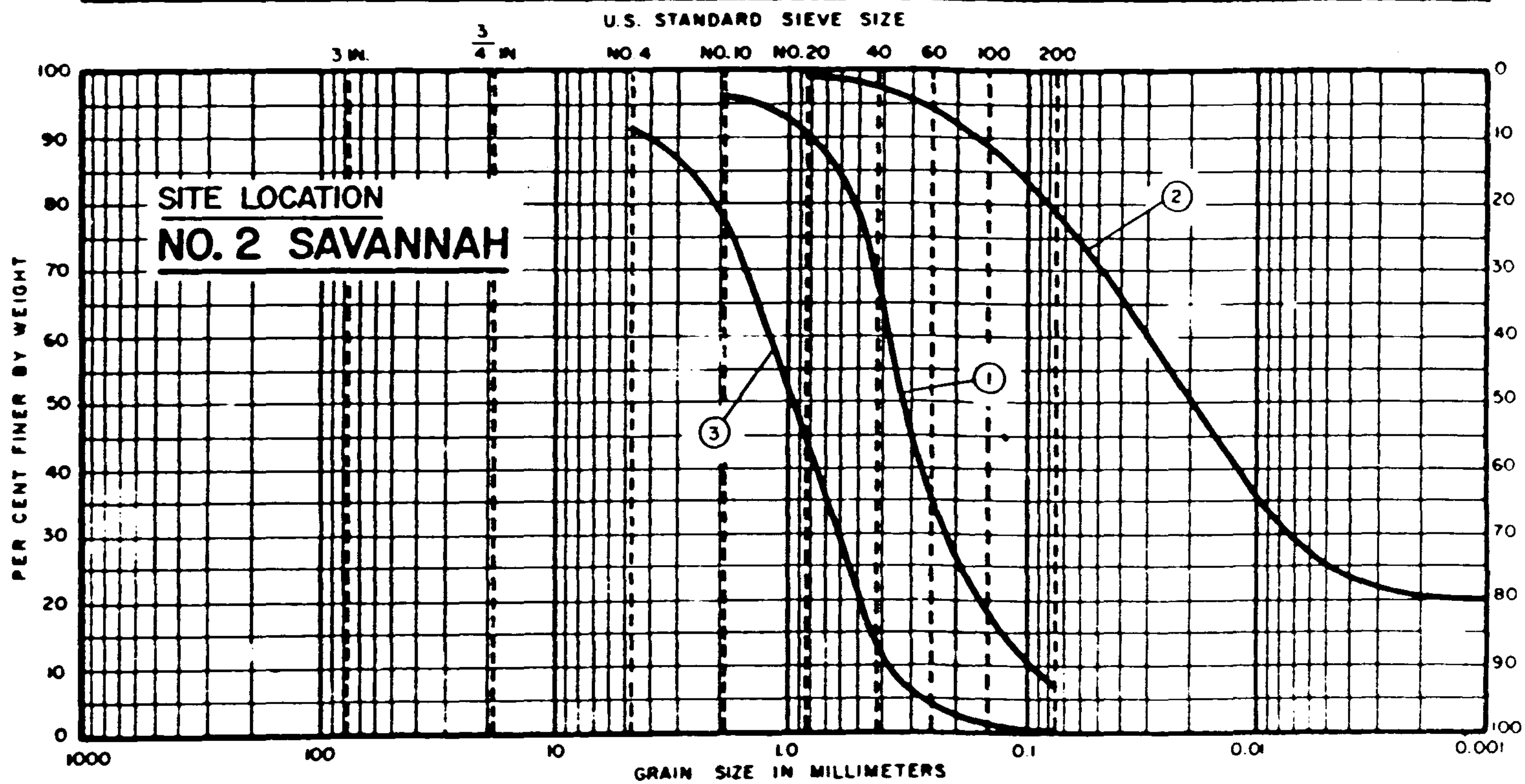
BORING	DEPTH	ELEV.	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SYMBOL	SOIL CLASSIFICATION	KEY
N - 197	1'-6"		1			SM	LIGHT BROWN SILTY FINE SAND	



GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

FIGURE 51

BORING	DEPTH	ELEV.	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SYMBOL	SOIL CLASSIFICATION	KEY
N-450	0'-8"		1			SP	LIGHT BROWN FINE TO MEDIUM SAND	1
N-450	1'-0"		2			ML	BLUISH-GREEN CLAYEY SANDY SILT	2
OUTLET HOLE	5'-6"		3			SP	LIGHT BROWN FINE TO COARSE SAND	3

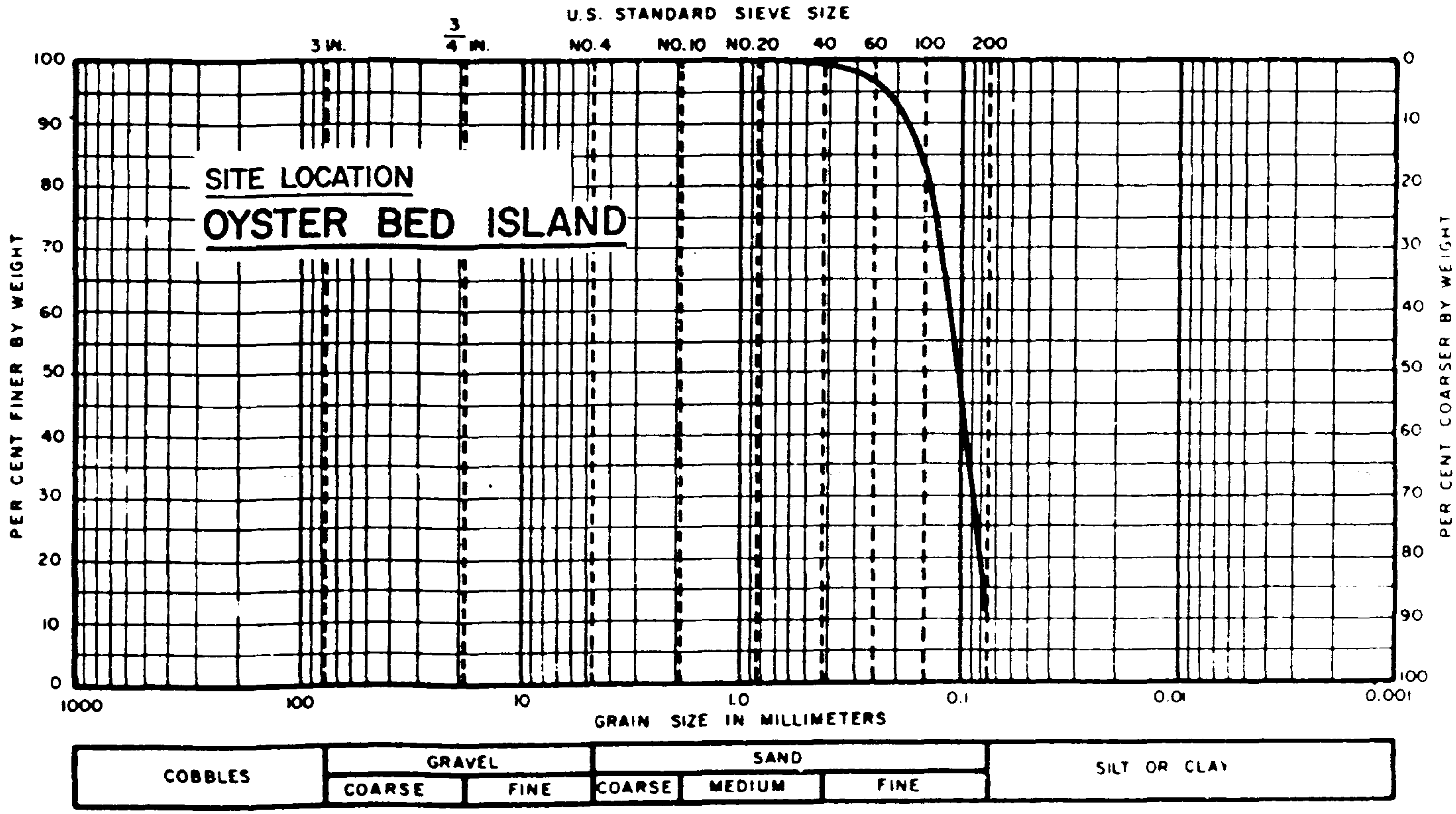


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

FIGURE 52

BORING	DEPTH	ELEV.	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SYMBOL	SOIL CLASSIFICATION	KEY
OUTLET HOLE	3'-6"		2			SP	LIGHT GRAY FINE SAND WITH TRACE OF SILT	



GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

FIGURE 53

46. The estimated relative coefficients of permeability were from high to medium for the sandy to silty sand samples (10^{-1} to 10^{-3} cm/sec) and medium to low for silty to silty clay samples (10^{-3} to 10^{-6} cm/sec). These values of the coefficients of permeability are with respect to vertical flow of water. Higher values on the order of 10 to 30 times the vertical coefficients are expected for horizontal flow of water. This is due to the layering of coarse and fine material caused by the different discharge locations within a site, in addition to the various gradients.

47. Table 2 presents the results of the chemical tests conducted on the samples of dredged material. Most samples were from depths of 0.5 to 2.0 ft. The range of percent of soluble Nitrate Nitrogen (NO_3^-) was 0.3 to 23.0 x 10^{-4}. A very low percent of soluble Carbonate ($CO_3^=$), less than 10 x 10^{-4} in 9 out of 14 tests, was found. The highest percentage was 135 x 10^{-4}, for the Upper Island of Coos Bay. The average pH of the 14 tests was 7.4 which is near neutral. The Chloride (Cl^-) percentage had the largest variance of all tests, ranging from 5 x 10^{-4} at Pedricktown-Penns Grove to 5500 x 10^{-4} at Oyster Bed Island. The volatile fractions were from 0.3 percent to 28.48 percent. The highest volatile fraction also had the highest field moisture content (143.9 percent), but the lowest volatile fraction had a 2.8 percent moisture content. In general, the higher the volatile fraction, the higher the field moisture content.

TABLE 2 - RESULTS OF CHEMICAL TESTS

Site	Location or Station	Depth of Sample ft	Soluble Nitrate Nitrogen (NO_3^-)* 10^{-4} x %	Soluble Carbonate* ($CO_3^=$) 10^{-4} x %	pH	Chloride* (CL^-) 10^{-4} x %	Volatile* Fraction %	Ash Content %	Field Moisture Content %
Tennessee Chute	N-0	1.0	1.4	<1.0	6.9	68	0.30	99.70	2.8
	N-270	1.0	3.2	<1.0	9.0	20	7.49	92.51	32.6
Drum Island	N-197	1.5	23.0	15.0	8.5	25	12.25	87.75	12.3
Coos Bay Upper Island	31	2.5	3.1	<1.0	5.9	75	28.48	71.52	143.9
	6	2.0	2.7	<1.0	3.3	100	15.02	84.98	76.6
	9	1.0	2.5	135.0	9.5	208	7.28	93.72	22.2
Oyster Bed Island	Outlet Hole	3.6	18.3	30.0	8.7	5500	1.35	98.65	13.6
No. 2 Savannah	Outlet Hole	5.5	1.5	75.0	9.4	290	1.62	98.38	1.3
	450	0.7	1.0	30.0	8.9	25	2.19	97.81	8.6
	450	1.0	3.3	<1.0	7.8	1300	6.98	93.02	88.4
Pedricktown-Penns Grove	2	0.5	2.85	<10	4.4	5	2.80	97.20	13.4
Penns Neck	4	0.5	20.5	<10	6.2	60	2.22	97.78	16.5
	5	0.5	10.5	<10	4.9	38	7.54	92.46	106.9
	7	0.5	0.3	<10	6.9	550	11.87	88.13	136.7

NOTE: Analysis conducted by Pacific Environmental Laboratory of San Francisco using "Standard Methods for the Examination of Water and Wastewater," American Public Health Association, and "Agriculture Handbook No. 60," U. S. Department Of Agriculture.

* Oven dry weight basis

48. The physical and chemical properties of dredged material dictate to a large extent the potential capability for developing habitat on a site. Slope, soil permeability, and grain size are among the more prominent modifying physical factors. Chloride ion concentration, pH, ash content, and soluble nitrate nitrogen have significant influence on plant succession and habitat development.

49. Attempts to correlate the physical, chemical, and biological factors were frustrated by the gradual slopes on most disposal areas, wide variability in chemical parameters, temporal differences of past dredging operations both within and between sites, and the apparent wide tolerance ranges of the plants growing on disposal sites.

50. Three sites were vegetated by willows. The Riverside site was very uniform in surface sediment (clay), elevation, and vegetation. Willow dominated over most of the middle of the site. At Tennessee Chute, willow again dominated; however, the surface sediment varied from poorly sorted sands to inorganic silt and elevation change was approximately 2 m. Chemical factors measured did not vary greatly between the two soil types, except that moisture and the volatile fraction were higher in the silt. The Dismal Swamp site has surface sediments which varied from sand to peat with little elevation variation. Again willow was dominant in the overstory. It appears that in the understory dogfennel, smartweed, and

goldenrod were more prevalent in sandy sediments, while blackberry, grasses, and honeysuckle were more often associated with the peat.

51. Of the two sites studied in the Philadelphia District, one, a portion of Pedricktown-Penns Grove, had never received dredged material. The sediment was fine sand and the slope shallow. However, a composite was dominant at one end of the transect line while grasses and arrow wood dominated the other. The portion which had received dredged material was covered with common reed. Penns Neck was completely covered with common reed.

52. All of the southeastern sites showed signs of zonation. The eastern portion of Drum Island was dominated by very hydrophylic vegetation. The more western portions were inhabited by less water-tolerant species. The dredged material characteristics similarly changed from clay with little sand to clayey sand and silty sand. No. 2 Savannah was largely comprised of a fine-to-medium, light-brown sand along the secondary transect with exceptions of some brown clayey sand. This latter condition was the only zone along this transect with significant vegetation assemblages. Along the primary transect, vegetation was found to be most dense where the topography was flat or surface sediments were clay or sandy silt layers. Similar conclusions can be reached when observing Oyster Bed Island data along the primary transect.

53. None of the MRGO sites showed any trends in vegetation assemblages. The sediments varied from sand, clay, and silt at Station 23.6; sand and clay at Station 41; to clay at Station 42. Stations 23.6 and 42 were relatively flat while Station 41 varied in elevation by approximately 3 m.

54. The three Coos Bay sites were all covered with sandy surface sediments; however, the chemical properties within one site showed wide variations (i.e. pH values from 5.9 to 9.5). Elevation changes were approximately 6.5 m. The three sites were in different stages of succession and as such showed different plant assemblages. There were no distinct correlations between chemical and physical factors except that salt-tolerant species such as glasswort (Salicornia) and seashore salt grass (Distichlis spicata) were confined to areas near sea level.

55. Chemical characteristics among all sites were quite variable and showed few correlations with either sediment type or plant assemblages. It appears that the widest range of the measured factors occurred in sandy soils. It was also these areas which exhibited the greatest variations in cover.

56. In general it appears that many plants inhabiting disposal sites exhibit wide tolerance ranges, because of the wide range of soil characteristics in which they were found. This is reasonable because most disposal sites are vegetated by species characteristic of early successional stages.

Goals and Objectives

57. Ultimately the outcome of this project should give CE District offices alternatives for dredged material disposal which will allow enhancement or development of wildlife habitat. Current CE dredging capabilities were considered in development of these alternatives. Since the definition of enhancement varies, the objectives of this research were aligned according to regional needs with concentration on valuable species and habitats adaptable to the region. Habitat enhancement includes improvement of habitat for game, non-game, or rare and endangered species. Additionally, habitats themselves may be endangered (i.e., wetlands), and their development can be considered a regional objective.

58. These studies did not cover every dredged material disposal site within a region. They did, however, cover a sufficiently broad expanse of confined sites with enough geographical distribution to allow extrapolation of results from one region to another. Those study areas chosen were selected because they exhibited wide ranges of sediment types, salinity regimes, and vegetation characteristics. Analysis of correlations of these factors with wildlife use and preference allows the widest range of options in habitat production. The fact that wildlife habitat or occurrence may not have been enhanced at an existing location was not involved in site

selection but must be addressed as part of the dredged material disposal alternatives for each region.

General Ecological Succession Considerations

59. Disposal of dredged material substitutes one environment for another. Consideration for the value of the present habitat, that produced under present CE disposal practices, and that which could be produced by enhancement procedures must be weighed. A discussion of regional habitat structure and succession is presented to aid in these value judgements. It must be noted that the progress of succession is theoretical and permutations to the system such as fire or man's activities can drastically alter direction and rate of succession.

Upland Succession

60. Succession is the natural phenomenon whereby communities progress from a young, simply structured system of low diversity and high net primary productivity to a mature, complex, diverse climax system (Odum 1971). In the terrestrial system, old fields, pastures and shrub areas represent early successional situations while hardwood or occasionally coniferous forests are more mature systems.

61. Old field succession occurs when land is abandoned after a period of extensive use, such as farming or pasture. Forbs and grasses predominate for several years after retirement. This early successional stage is very productive

(net community productivity), low in diversity, highly susceptible to external permutations, and has poorly organized stratification and spatial heterogeneity (Odum 1971). A major value of plant species of this successional stage is their ability to vegetate barren areas quickly. Plant species characteristic of early successional stages are often adapted for rapid colonization, rapid growth rate, and ability to withstand harsh environmental conditions.

62. Shrubs invade the herbaceous stage and eventually become codominant with forbs and grasses. Shrub or shrub-herb stages exhibit some characteristics of early and mature successional systems. They are intermediate in net community productivity and are more stratified than herb-dominated communities. As such, they often provide excellent food and cover for wildlife (Tubbs and Verme 1972).

63. Tree species invade the shrub stage and eventually close the forest canopy. Successful perpetuation is determined by the ability of the species to withstand intense competition for light, space, moisture, and nutrients. Those species which are the most successful competitors generally comprise a stable forest community.

Wetland Succession

64. The succession of open waterbodies normally leads to the production of shallow wetland areas which also undergo successional changes. Wetland succession occurs as the area is gradually filled with materials eroded from its

basin and from the accumulation of the dead organic materials produced in the wetland itself. Freshwater marshes gradually change from a cattail marsh to a shrub swamp followed by a wooded swamp. As wooded swamps are filled, a truly terrestrial environment is formed (Martin 1959). Changes in the water table, however, influence both the rate and direction of succession. For example, while with an unchanging water table a cattail marsh would be expected to gradually fill to become a shrub swamp, this process could be reversed if the water table rose above that in which the shrubs could survive. Many wetland types are often associated with streams and rivers. In these cases the successional direction and rate is largely controlled by the meandering of the water course.

65. Tidal marshes, especially saltwater tidal marshes, do not exhibit the successional pattern described above. Salt marshes are vegetated land surfaces at the edge of the sea, alternately flooded and drained by tides. They are, in a geological time frame, a transitory feature developing where suspended material, mostly of terrestrial origin, is deposited in quiet areas of estuaries, bays, and lagoons. When the surface of these deposits reaches an elevation above the low tide level, plants begin to colonize. Their root systems stabilize the sediments and further accretion occurs until the surface reaches mean high tide levels. The rate of deposition is dependent on the supply of sediment (Ragotzkie 1960). Sea level changes also affect the direction and rate of development.

Habitat Enhancement or Development

66. The enhancement or development of an environment for wildlife is accomplished by establishing the rate and direction of succession and arresting successional progression at some point maximally suited to the objectives.

67. In order for succession to proceed unhindered, a site must be abandoned completely. However, succession can continue where the frequency and volume of disposal do not completely destroy existing vegetation. The more infrequent the disposal in a confinement, the greater are chances for succession to continue and plant and animal components of communities to stabilize. For example, an aerial examination of Oyster Bed Island (Fig. 29) shows the relationships of disposal frequency and development of several stages: older sites are more heavily vegetated. No. 2 Savannah (Fig. 26) has been the subject of repeated and frequent disposal and, consequently, is poorly vegetated.

68. The volume of disposal material influences the level of vegetation inundation and the range of sediment dispersal in any given containment area. Mature wooded vegetation in the Tennessee Chute site has been able to survive repeated disposal operations because of its moisture tolerance and height. Vegetation that has developed since the initial disposal has been reduced or limited to areas of minimal inundation. Cedar trees and palmettos on some coastal disposal sites have persisted where inundation levels

have been low enough to prevent plant burial and to allow physiological functioning.

69. Early abandonment of sites will allow them to begin the successional process sooner. The use of smaller confinements within disposal sites will shorten disposal time so that revegetation may proceed. Drum Island is divided into three sections. The westernmost confinement is no longer used for disposal of dredged materials; the result is that vegetation rapidly developed and succession proceeded unhindered until it was deliberately arrested at a shrub stage by brackish water inundation. Large sites near No. 2 Savannah were constructed to receive a greater volume of dredged material. Consequently they will be utilized for a long time period and have ecological succession continually arrested at early stages over wide areas.

70. To speed natural succession rates of abandoned areas, several alternatives are available. Terrestrial succession will generally develop more readily on smaller or more narrow disposal areas. Such geometric and size factors facilitate the establishment of colonizer species over the whole disposal area. Mounds may be constructed in functioning disposal areas which will develop vegetation during disposal activities and serve as seed sources after abandonment. Sprigging and seeding of areas can speed succession by increasing the colonization rate of isolated sites and bare areas and by the initiation of biological soil conditioning.

This conditioning includes the loosening and aeration of the soil and the buildup of an organic soil layer.

71. Successional direction as well as rate may be determined by physical characteristics of the sediment. In some cases some soil management may be required to achieve wildlife enhancement goals. For example, sandy disposal material is low in nutrients and retains moisture poorly so that colonization is slow. In order to increase the rate of successional development in such areas, an impermeable layer such as a silty clay to clay would reduce leaching. Conversely, sand can be incorporated into fine-grained disposal material to facilitate leaching of salts. Acid soils may be neutralized and textural properties improved by adding lime in some areas (Gold 1971, Gosselink et al. 1972). Fertilizing can be used to supplement levels of nutrients.

72. Dredged material and its accompanying water component may further regulate the direction and rate of ecological succession. For example, introduction of saline water to an area inhabited by nonhalophytic plants will kill the plants and retard succession. Material dredged from the Delaware River generally carries with it seed and root matter of the common reed (D.N. Riemer, Personal Communication), so the majority of disposal sites in this area are covered with this species regardless of what previously existed. (Common reed here represents a climax stage.) Wherever salt marshes are used as disposal areas, such as at Oyster Bed Island and

No. 2 Savannah, and tidal flushing ceases, terrestrial habitats are created in place of tidal grassland ecosystems.

73. The arrestment of succession at a desired stage can be accomplished by burning, cutting, or herbicide application. In addition, dredged material or decanted water may be used to stop succession. The inundation process has been used to manage a valuable wildlife area on Drum Island, where vegetation growth in a heron colony is managed by periodic flooding with decanted water.

74. Dredged material disposal procedures result in habitat types which are often specific to a geographical area or target species. It is possible, however, to create habitat types significantly different from original types. Freshwater wetlands or aquatic habitats can be developed in terrestrial environments where water loss from leaching and evapotranspiration is equal to or less than the volume of rainfall or input. Upland habitats can be created where water loss rates exceed water input rates. A mixture of habitat types can also be accomplished and may be necessary to enhance habitat value for target species. The regional discussions to follow will elaborate on the specific alternatives available to Districts in each region.

General Constraints to Enhancement Alternatives

75. The best approach to wildlife habitat enhancement is to focus on only those faunal species which are indigenous to a particular area. For example, the stocking of northern pike in the south would be unfeasible because temperatures reach levels above its tolerance. Introduction of exotic species into a region as an enhancement alternative is often ecologically undesirable and is not recommended.

76. To help maximize success of the following alternatives, careful attention should be paid to the timing of subsequent disposals on a site if there are to be any, and the timing of faunal and floral introduction onto the site. The enhancement goals themselves should take into account the possible necessity of continuous disposal. Disposal operations should be coordinated with seasons and stages in the lives of target species.

77. Pollution levels in sediments and water should be evaluated, especially where human harvest or consumption of target species is involved. The physical or chemical type of dredged material needed to create the desired habitat may be unavailable and thus limit some enhancement alternatives, or require that the desired materials be brought in at additional cost. Time will be the limiting factor in the establishment of a mature habitat.

78. CE personnel were questioned about legal or economic constraints in the disposal of dredged material but few such

constraints were cited. Typically, the constraints related to restrictions imposed by the U.S. Department of the Interior or to the expiration of land easements. The EPA criteria for nonpolluted dredged material were not mentioned.

79. To obtain information concerning laws or restrictions regulating the disposal of dredged material on land in the vicinities of the sites, the EPA regional offices in Philadelphia, Atlanta, Chicago, Dallas, and Seattle were contacted. All of the personnel talked with at these offices agreed that, in general, permits for dredging and disposal are issued on a case-by-case basis. Section 404 of Public Law 92-500, Federal Water Pollution Control Act Amendments of 1972, was the most frequently mentioned guideline. Section 404 reads as follows:

> "Sec. 404. (a) The Secretary of the Army, acting through the Chief of Engineers may issue permits, after notice and opportunity for public hearings for the discharge of dredged or fill material into the navigable waters at specified disposal sites.
>
> "(b) Subject to subsection (c) of this section, each such disposal site shall be specified for each such permit by the Secretary of the Army (1) through the application of guidelines developed by the Administrator, in conjunction with the Secretary of the Army, which guidelines shall be based upon criteria comparable to the criteria applicable to the territorial seas, the contiguous zone, and the ocean under section 403 (c), and (2) in any case where such guidelines under clause (1) alone would prohibit the specification of a site, through the application additionally of the economic impact of the site on navigation and anchorage.
>
> "(c) The Administrator is authorized to prohibit the specification (including the withdrawal of specification) of any defined area as a disposal site, and he is authorized to deny or restrict the

use of any defined area for specification (including the withdrawal of specification) as a disposal site, whenever he determines, after notice and opportunity for public hearings, that the discharge of such materials into such area will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas. Before making such determination, the Administrator shall consult with the Secretary of the Army. The Administrator shall set forth in writing and make public his findings and the reasons for making any determination under this subsection."

80. Other policies followed by some of the regional offices included the EPA's Protection of Nation's Wetlands Policy Statement (1973) and Section 10 of the River and Harbor Act of 3 March 1899. No permits for dredging in coastal zones are issued without approval of the governing state agency. However, the Secretary of Commerce may allow the permit if the proposed dredging is consistent with the objectives of the Coastal Zone Management Act of 1972.

81. In addition, EPA's Office of Legislation, Intergovernmental Relations Division, indicated that Public Law 91-190, the National Environmental Policy Act of 1969, is used as a general guideline. It was stressed, however, that because of the lack of more specific regulations, each case is weighed individually.

82. Major economic constraints involve the costs to initiate and carry through suggested alternatives for habitat development and/or improvement. Equipment such as draglines and bulldozers would be necessary to partition sites by

diking. Some costs would be incurred from the more frequent relocation and/or modification of hydraulic dredge disposal pipes to a site. Along with equipment cost are manpower costs for operation, supervision, and habitat management.

83. The types of dredges being used at each site have no particular advantage or disadvantage with respect to constraints. Each dredge used open pipeline disposal. Several methods of altering the way the open-pipe material is distributed to the disposal area can be envisioned, but the merits of enhancing habitat are limited. For example, using a pipeline extended across the site or a portion thereof, with perforated outlet holes along the length, would distribute dredged material more evenly; however, the benefits of this technique are not believed proportional to the expected enhancement versus pumping impediment of the dredging operation. Baffling of the discharge pipe has been suggested, but again the merits as related to habitat enhancement of the 15 sites studied would be few, if any. For further discussion on disposal systems and various alternatives, reference is made to Boyd et al. (1972).

Regional Constraints, Successional Patterns, and Alternatives

Great Lakes Region

84. Constraints. The most problematic constraint in portions of the Great Lakes area is the contamination associated with dredging operations. Refinery, industrial, and

municipal wastes in sediments may enter the water column and then the disposal area during the disturbance of dredging. Legal constraints are often associated with disposal of contaminated dredged materials. These wastes are potentially harmful to wildlife, particularly aquatic and wetland species. Problems are most acute in impoundments where leaching can occur.

85. Petroleum wastes were detected at disposal sites during studies in this region. Current water pollution abatement legislation and other measures, are, however, resulting in lower contaminant levels. For example, less oil is currently present in the Detroit River than in past years; industrial wastes are now the most prominent pollutants (M.A. Cooper, Personal Communication). Industrial and petroleum wastes are still found in material in the Memphis District area (A.B. Richardson, Personal Communication).

86. Although not a constraint to habitat enhancement, the scarcity of land along dredged waterways in the Great Lakes Region poses a severe constraint to future dredged material disposal. Should the frequency of disposal to small sites be increased due to scarcity of sites, the development of desired habitat could be hampered.

87. Successional patterns. Discussion of successional stages to be expected in the Great Lakes Region concentrates on areas studied during the field phase of this investigation.

a. <u>Upland habitat, Detroit District</u>. The vegetation climax for sites in the Detroit and Toledo area is in an area classified as beech-maple forest, dominated by American beech and sugar maple (Braun 1950). These climaxes are often modified by edaphic and other environmental factors to produce a situation dominated by species other than these hardwoods.

In the herbaceous stage, forbs and grasses dominate immediately after abandonment for approximately ten years. The principal components are Kentucky bluegrass, milkweed, sorrel, panicgrass, and bush clover (Wiegert and Evans 1964). Numerous animals feed on these species, including bobwhite, sparrows, ring-necked pheasants, ground squirrels, eastern cottontails, and deer mice (Wiegert and Evans 1967, Martin et al. 1951).

Shrubs begin invasion of the herbaceous stage after approximately five years and are co-dominant or dominant for 10 to 15 years. The principal components at this stage include elder, white ash, black cherry, sumac (staghorn, smooth), quaking aspen, and some herbs from the previous stage. Examples of animals that feed in these shrub habitats are bobwhite, cedar waxwings, ruffed grouse, ring-necked pheasants, American robins, starlings, eastern bluebirds, gray catbirds, white-tailed deer, white-footed mice, and eastern cottontails (Martin et al. 1951).

In the young hardwoods stage, which lasts 20 to 40 years, tree species that became important in the shrub stage develop into a wooded stage that is gradually invaded by more shade-tolerant mature hardwoods. The principal components at this stage include quaking aspen, white ash, sweetgum, black cherry, and shrubs of the previous stage (willow in damp sites). Species which feed in this habitat are the bobwhite, eastern goldfinch, ruffed grouse, purple finch, and white-footed mouse (Martin el al. 1951).

The climax hardwood is the final wooded stage possible in the existing climatic regime of an upland area. Shade-tolerant hardwoods gradually dominate over young hardwoods after 30 to 40 years. The principal components are American beech, sugar maple, American elm, and white oak. Numerous animals, especially game species, spend large amounts of time in these woods although they often feed in shrub and field areas. The blue jay, evening grosbeak, ruffed grouse, raccoon, eastern chipmunk, and white-footed mouse (Martin et al. 1951) feed on seeds of these trees and on shrub and ground cover species. Others like the tufted titmouse and red-bellied woodpecker use woods as nesting and carnivorous feeding habitat.

b. Upland habitat, Memphis District. The vegetation climax for sites in the Memphis District is in an area classified as the Mississippi alluvial floodplain forest dominated by sweet gum and various oaks (Braun 1950). This climax is often modified by edaphic and other environmental factors to produce a situation dominated by species other than these hardwoods.

In the herbaceous stage, forbs and grasses predominate immediately after abandonment for approximately ten years. Principal components at this stage include goldenrod, aster, milkweed, and fleabane and daisies (Kelly et al. 1969). Many animals (e.g., mourning doves, bobwhite, red-winged blackbirds, eastern meadowlarks, tree sparrows, savannah sparrows, eastern cottontails, white-footed mice; Martin et al. 1951) forage in this highly productive area.

Shrubs begin invasion of the herbaceous stage after approximately five years and are co-dominant with forbs and grasses or dominant for 10 to 15 years. Principal components at this stage include sassafras, sumac (staghorn, smooth), small hackberries and elms, and some herbs from the previous stage. Examples of fauna that feed on and among these shrub species are the great crested flycatcher, American robin, eastern phoebe, starling, gray catbird, bobwhite, white-tailed deer, white-footed mouse, and eastern cottontail (Martin et al. 1951).

Climax hardwood is the final wooded stage possible in the existing climatic regime of an upland area. Shade-tolerant hardwoods gradually dominate over young hardwoods after 30 to 40 years. Climax hardwoods will dominate until the system is subjected to major perturbations such as fire or clearing.

Principal components at this stage include sweetgum, southern red oak, swamp red oak, tupelo, red maple, and willow. Numerous animals, especially game species, spend large amounts of time in these woods although often feeding in shrub and field areas. Other fauna such as the blue jay, tufted titmouse, evening grosbeak, red-bellied woodpecker, raccoon, eastern chipmunk, and white-footed mouse (Martin et al. 1951) feed on seeds of these trees and on shrub and ground cover species or utilize this habitat for nesting or carnivorous feeding.

c. Wetland habitat, Detroit District. The vegetative cover of inland shallow fresh water marshes in this region is principally common reed, rice cutgrass, sedge, and cattail (Shaw and Fredine 1956). These marshes, in conjunction with inland deep fresh water marshes, are used as feeding and nesting areas by waterfowl (Shaw and Fredine 1956). Other animals which use the food resources of these areas are beaver, white-tailed deer, mink, muskrat, raccoon (Martin et al. 1951), snapping turtles, water snakes, and the mud-puppy (Conant 1958).

Shrub swamp areas, which are vegetated primarily by alder, willow, and buttonbush, are considered less valuable for waterfowl and are used only to a limited extent for feeding and nesting (Shaw and Fredine 1956). Other animals, including white-tailed deer, beaver, raccoon, muskrat, and mink, use food materials produced in the shrub swamp.

Wooded swamps contain water-logged soils to within an inch of the surface during the growing season and are often covered by as much as a foot of water. Red maple, black spruce, tamarack, arborvitae, balsam, and black ash make up the major vegetative components (Shaw and Fredine 1956). As with shrub swamps, waterfowl usage is low; however, they are used more by resident species. Some animals likely to use wooded swamps include the wood duck, ruffed grouse, woodcock, white-tailed deer, beaver, mink, muskrat, and raccoon (Martin et al. 1951), massasauga, water snakes, rattle snakes, spring peepers, and leopard, green, and bull frogs (Wright and Wright 1949, 1957).

d. Wetland habitat, Memphis District. Inland shallow freshwater marshes located in this region are covered by arrowhead, maidencane, sawgrass, and pickerelweed and are used somewhat by waterfowl, mostly as a supplemental feeding area (Shaw and Fredine 1956). The food produced in this environment is known to be eaten by white-tailed deer, mink, muskrat, raccoon, and skunk (Martin et al. 1951). Shrub swamps in this area have similar plant and animal assemblages as those in the Detroit District. Principal species of the wooded swamps are tupelo gum. The faunal component includes wood duck, woodcock, white-tailed deer, and raccoons.

Reptiles and amphibians are represented by a greater number of species here than in the Detroit region. (Conant 1958).

e. Open-water habitat, Detroit and Memphis Districts. Submergent plants such as pondweed and water milfoil are to be expected in the zone which is shallow enough for light to penetrate to the bottom but deep enough that floating-leaved plants such as waterlilies cannot grow and shade them out. In even more shallow zones, emergent plants such as cattails and arrowhead can be found. Minnows, sunfish, suckers, and bullhead are expected.

88. The alternatives described below represent options available to Districts in the Great Lakes Region. General methodologies to attain desired habitats and biotic components are presented. A biologist and/or soils engineer should be at each site during habitat enhancement activities to refine the methodologies.

89. The target species should be defined, its habitat requirements identified, and suitable vegetative cover, food and water resources, and living space provided. Once these requirements have been met, active habitat management must often be continued to control population levels and ecological succession. In order to select target species, the advice of biologists in the region was sought concerning valuable wildlife species. Their suggestions, along with the feasibility

of appropriate habitat preparation for the species, were then considered in the final selections.

a. Upland habitat. The following game and fur-bearing animals can benefit most from habitat development on upland portions of disposal areas:

	Page*
Mourning dove	C1
Ruffed grouse	C3
Woodcock	C6
Bobwhite	C9
Turkey	C14
Ring-necked pheasant	C17
White-tailed deer	C19
Eastern cottontail	C22
Woodchuck	C24
Canada goose	C25

* See the indicated page in Appendix C for general habitat requirements and management.

In order to provide the appropriate upland habitats for the target species, certain manipulations may be necessary. Compartmentalizing or partitioning sites and rotating disposal locations within sites should be considered for habitat beyond the earliest successional stages (see experimental format for Grassy Island, MRGO, and Savannah test areas as examples). In large confined disposal areas, particularly where disposal is frequent, mounds can be created which are at an elevation above the disposed dredged material. These will serve as seed sources to speed establishment of vegetation after disposal.

Once the dredged material is relatively dry, physical characteristics should be determined. Soil pH near neutrality is desirable; application of lime will be needed if the soil is acidic. Nutrient enhancement by fertilization may be required. Soil drainage characteristics may need to be modified. If pollutants are a possible constituent of the dredged material, tests should be performed to confirm their presence or absence. Attention should be paid to insure that desired vegetation will not take up toxic materials from buried soil and render them available for faunal consumption. Periodic checks for pollutants in vegetation should be undertaken where this event is a likelihood.

After the site has been properly prepared, the area can be seeded or sprigged with herbs and grasses, or planted with tree seedlings or shrubs, although vegetation may volunteer if sufficient natural seed sources are available in the vicinity. At this point the site may be left unperturbed to undergo natural succession to the desired stage. Any perturbation to the system such as mowing, burning, or further disposal of dredged material would arrest or lengthen the successional process.

b. <u>Freshwater wetland habitat</u>. The following game animals may specifically benefit by enhancement schemes on wetland areas of dredged material disposal sites:

	Page
Canada goose	C25
Mallard	C27
Black duck	C29
Wood duck	C31
Muskrat	C33

Many species of waterfowl would find the developed habitat suitable. Those mentioned above have had substantial information generated in the literature concerning their management and are representative of this group of game animals.

Freshwater wetlands may be established in terrestrial environments (see Grassy Island and Savannah test areas, pages 169 and 172, for details). Techniques for this include partitioning disposal areas to allow settling of suspended sediments, and creating depressions and soil characteristics to allow water to pond. A confinement which is to become a freshwater marsh may require flushing with rainwater to reduce salinity levels. To allow succession to proceed to the desired stage in disposal sites which are frequently used, compartmentalization will be necessary to prevent successional retardation. Stocking the site with desired fur-bearers, forage plants, marsh grasses, and waterfowl, such as commercially available mallards, could be done. Vegetation removal through use of herbicides and waterlevel management may be necessary to maximize waterfowl use. Fur-bearers may also require management. Evaluations should be made to determine best population levels for fur-bearers and to maximize the waterfowl carrying capacity.

c. Open-water habitat. Open-water habitats may be created on confined disposal sites by varying the elevation of the area and/or dikes and by lining the depressed areas with relatively impermeable substrates. Adequate water supply may be obtained from rainfall, diversion of a portion of a nearby water course, or pumping. Shallow open-water areas provide very good habitat for waterfowl. Planting of appropriate aquatic vegetation should provide excellent feeding areas for geese and pond ducks.

Largemouth bass (page C54) and bluegill (page C53) communities are easily established by using proper stocking techniques in newly created ponds. The pond should consist of shallow areas about one m in depth, and at least one deep area in excess of six m. At least 10 percent of the bottom substrate in the shallow areas should provide a firm base for largemouth bass nesting (Curtis 1949, Simon 1951). Sand or gravel would suffice. Bluegill are less restricted in their spawning habits and can nest on various substrates including mud (Calhoun 1966). The introduction of aquatic vegetation would provide a food source and cover for prey organisms. Additional cover consisting of boulders, sunken logs, or other debris would provide additional protection as well as increase surface area for algal production (Reid 1961).

Stocking of largemouth bass at the rate of 100 fry/acre and bluegill at 500 to 1000 fry/acre was recommended by Regier (1963). Planting these fish in spring would allow the best chance for their survival, because during this period the greatest food supply exists. Assistance with stocking is given by many state fisheries departments when public access is allowed to such waters.

After initial stocking, periodic examination and the application of maintenance procedures may be required. A largemouth bass-bluegill community can become imbalanced with an over-abundant bluegill population that retards largemouth bass numbers by preying too heavily on the bass fry. The bluegill population then becomes stunted because of the increased competition for available food and decrease in predation (Calhoun 1966). This can be corrected by several methods, one being the addition of another predator species such as northern pike (K.D. Carlander, Personal Communication). Another method is selective elimination of the overabundant species (Calhoun 1966).

The presence of pollutants in the water and sediments is undesirable as toxic conditions may arise or pollutants may enter the food chain. Covering the sediments with an impermeable layer should isolate them from the biological community. Since plant roots may penetrate to the polluted level, vegetation should be periodically examined to determine if uptake is occurring.

d. Other habitat. The best goals for habitat enhancement for other species in the Great Lakes Region area include shorebird feeding and gull and tern nesting. Possibly the most difficult of these habitat usage goals to attain is the development of nesting habitat for colonial bird species.

A nesting habitat requires that adequate feeding grounds should be nearby, human intrusion should be at a minimum during and just prior to nesting seasons, and proximity to a shoreline is warranted. Many species require island environments and most need sand for a nesting substrate. Shorebird feeding habitat can be readily created by providing a shallow water environment. The soil composition is relatively unimportant as long as pollution is not a problem and the sediment will retain water. To discourage significant macrophytic vegetation accumulation, water levels should be varied over a relatively wide range with use of waters from dredged material disposal. Burning in the winter to kill emergent freshwater vegetation may be conducted.

Wetland and terrestrial ecological succession should be maintained at early stages for successful shorebird feeding habitats. Aquatic succession from an oligotrophic to eutrophic state can be allowed to proceed unimpeded up to the point where emergent macrophytic vegetation such as cattails, reeds, sedges, and rushes begin significant development.

Several shorebird feeding habits, requirements, and habitat development schemes are listed on page C38. Target species which form nesting colonies include:

	Page
Herring gull	C42
Ring-billed gull	C43
Caspian tern	C47
Forester's tern	C50

North Atlantic Region

90. Constraints. Pollution levels of waters and sediments along the Delaware River should be considered in designing viable wildlife enhancement alternatives. Refinery pollutants (Mr. H. H. Griffith, Personal Communication) and municipal wastes enter the rivers and are potentially harmful to wildlife, particularly aquatic and wetland species. The problems would be most acute in impoundments where leachates of sediments can accumulate. As water qualities are improved, problems associated with polluted dredged material should also improve. Still, initial dredging may mix and disturb polluted sediments which were buried prior to water-quality improvement activities.

91. Legal constraints are prominent in much of this region. Disposal in salt marsh and estuarine areas of New Jersey is regulated by the New Jersey Environmental Protection Agency and U.S. Fish and Wildlife Service in terms of location and frequency of disposal (Mr. H. H. Griffith, Personal Communication).

92. The scarcity of land disposal sites in the North Atlantic Region is a potential constraint to dredging in upper reaches of navigable waterways. The development or enhancement of suitable wildlife habitat would then be constrained by more frequent diposal to active sites.

93. Successional patterns. Discussions of successional stages to be expected in the North Atlantic Region concentrate on areas studied during the field phase of this report.

a. Upland habitat, Philadelphia District. The vegetation climax of sites in the Philadelphia District is an oak-chestnut forest dominated by white and northern red oaks (Braun 1950). This climax is often modified by edaphic and other environmental factors to produce a situation dominated by species other than the hardwoods. Such is the case in the dredged material sites where common reed is the predominant species.

The herbaceous stage is vegetated principally by panicgrass, bear grass, bluegrass, fescue, goldenrod, aster, milkweed, smartweed, and pokeweed. Species including ring-necked pheasant, mourning dove, bobwhite, tree sparrow, savannah sparrow, red-winged blackbird, eastern meadowlark, eastern cottontails, and white-footed mice forage in this highly productive area (Martin et al. 1951).

The herbaceous stage gradually gives way to the shrub stage, which is dominated by elder, white ash, black cherry, sumac (staghorn, smooth), and some herbs from the previous stage. Examples of animals that feed in the shrub environment are the ring-necked pheasants, eastern bluebird, gray catbirds, American robins, starlings, cedar waxwings, white-tailed deer, white-footed mice, eastern cottontails, and bobwhite (Martin et al. 1951).

Light-tolerant tree species invade the shrub habitat and produce a young hardwood stage. The principal vegetative components are white ash, sweetgum, black cherry, and shrubs of the previous stage. Animals which feed within this habitat are bobwhite, purple finch, eastern goldfinch, ruffed grouse, and white-footed mice (Martin et al. 1951).

The climax forest follows the young hardwoods and consists primarily of white oak, northern red oak, red maple, American beech, and hickories. Numerous animals, especially game species, spend large amounts of time in these woods although they may feed in shrub and field areas. Some non-game species utilizing woods include the blue jay, tufted titmouse, red-bellied woodpecker, evening grosbeak, eastern chipmunk, white-footed mouse, and raccoon (Martin et al. 1951).

b. Upland habitat, Norfolk District. The dominant vegetation of sites in the Norfolk District is the Southeastern evergreen forest region dominated by cypress and tupelo or various oaks (Braun 1950). This type is often modified by edaphic and other environmental factors to produce a situation dominated by species other than these hardwoods.

Forbs and grasses predominate in old fields immediately after abandonment. The principal components are grasses such as crabgrass, broom sedge, and fescue and goldenrod, aster, milkweed, and dogfennel (Kelly et al. 1969). Numerous animals including bobwhite, tree sparrows, savannah sparrows, mourning doves, red-winged blackbirds, eastern meadowlarks, white-footed mice, and eastern cottontails (Martin et al. 1951) forage in this area.

Shrubs begin invasion of herbaceous stage after approximately five years and are co-dominant with forbs and grasses or dominant for 10 to 15 years. The principal plant components are sassafras, sumac (staghorn, smooth), small hackberries, elms, and some herbs from the previous stage. Examples of animals that feed among these shrub species are the great-crested flycatcher, eastern phoebes, gray catbirds, American robins, starlings, bobwhite, cedar waxwings, eastern cottontails, white-tailed deer, and white-footed mice (Martin et al. 1951).

Tree species that became important in the shrub stage develop into a young wooded stage. The principal plant components are white ash, sweetgum, hackberry, elm, and shrubs of the previous stage. Animals which feed on and among these species are bobwhite, purple finch, eastern goldfinch, white-footed mice, and white-tailed deer (Martin et al. 1951).

Climax hardwood is the final wooded stage possible in the existing climatic regime of an upland area. Shade-tolerant hardwoods gradually dominate over young hardwoods after 30 to 40 years. Principal components are sweetgum, cypress, southern red oak, swamp red oak, white ash, and willow. Numerous animals, especially game species, spend large amounts of time in these woods although often feeding in shrub and field areas. Other fauna such as the blue jay, tufted titmouse, red-bellied woodpecker, evening grosbeak, raccoon, eastern chipmunk, and white-footed mouse (Martin et al. 1951) feed in this habitat.

c. Wetland habitats, Philadelphia District. The vegetative cover of inland shallow freshwater marshes in this region is principally common reed, rice cutgrass, sedge, giant bur-reed, cattail, arrowhead, pickerelweed, and smartweed (Shaw and Fredine 1956). These marshes, in conjunction with inland deep freshwater marshes, are used as feeding and nesting areas by waterfowl (Shaw and Fredine 1956). Other animals which use the food resources of these areas are beaver, white-tailed deer, mink, muskrat, and raccoon (Martin et al. 1951), snapping turtles, and water snakes (Conant 1958).

Shrub swamp areas which are vegetated primarily by alder, willow, buttonbush, dogwood, and swamp privet are considered less valuable for waterfowl and are used only to a limited extent for feeding and nesting (Shaw and Fredine 1956). Other animals, including white-tailed deer, beaver, raccoon, muskrat, and mink, use the food materials produced by the plants of the shrub swamp.

Wooded swamps contain waterlogged soils to within an inch of the surface during growing season and are often covered by as much as a foot of water. Red maple and black ash make up the major vegetative components (Shaw and Fredine 1956). As with shrub swamps, waterfowl usage is low; however, wooded swamps are used more by resident species. Those animals likely to utilize wooded swamps include wood duck, ruffed grouse, woodcock, white-tailed deer, beaver, mink, muskrat, raccoon, water snakes, woodland salamanders, leopard frogs, green frogs, and bullfrogs (Conant 1958).

The salt marshes of the east coast of the United States can be divided into two general types primarily related to sediment characteristics. The New England type salt marsh occurs from Maine to New Jersey where the shore is composed largely of hard rock. Silt is limited and the marsh substrate is largely fibrous marine peat. Southward from New Jersey to northern Florida and into the Gulf Coast softer rocks have eroded, providing large amounts of silt. Sediment transported downriver supplies a major portion of salt marsh substrate material in this area. Here the marshes are wide and relatively flat, and have a substrate made of soft grey silt (Cooper 1969).

The New England type salt marsh has a rather clear zonation (Chapman 1940, Redfield 1972, and Nixon and Oviatt 1973). Smooth cordgrass occurs in the intertidal regions in dense stands. Depending on the tidal amplitude and the slope of the shore, the belt may vary from a fringe next to the water to wide areas. Landward of the smooth cordgrass zone, at a slightly higher elevation, there is a well-developed zone dominated by saltmeadow cordgrass mixed with seashore salt grass. In zones of higher elevation are black grass and at the upland edge of the marsh a fringe of switchgrass and freshwater cordgrass mixed with many other species.

Nixon and Oviatt (1973) stated that animals inhabiting a Rhode Island marsh included the mud fiddler crabs, marsh snails, and ribbed mussels. All of these species occurred at lower densities than reported from studies of southern marshes. For example, the mud fiddler crab was reported to have population densities of 2.7 ± 3.8 per m^2 in New England and 205 per m^2 in Georgia (Wolf et al. 1972). Mammals observed in the Rhode Island marsh included mice, voles, muskrats, and raccoons. All were in low numbers. Ducks, gulls, and terns made up the three major types of birds inhabiting the marsh and nearby waters. In addition the great blue heron, snowy egret, green heron, black-crowned night heron, mute swan, clapper rail, solitary sandpiper, lesser yellowlegs, and belted kingfisher were sighted in the marsh area along with a few visitors from nearby woodlands.

Marshes of New Jersey and Delaware show characteristics of both the New England and more southern marshes. As in New England marshes, smooth cordgrass inhabits a relatively limited zone with saltmeadow cordgrass making up the largest zone. However, smooth cordgrass shows a taller growth form near creeks, a pattern typical of southern areas. Black grass grows at higher elevations.

d. <u>Wetland habitat, Norfolk District</u>. Inland freshwater meadows located in this region are covered by sedges, rushes, red top, and reedgrass (Shaw and Fredine 1956). They are used by waterfowl, mostly as a supplemental feeding area, and by pheasant, eastern cottontail, white-tailed deer, mink, muskrat, raccoon, and striped skunk (Martin et al. 1951).

Shrub swamps in this area have similar plant and animal assemblages as those in the Philadelphia District. Wooded swamps contain a much more diverse group of trees farther south in the Norfolk District than in the Philadelphia District. Principal trees are water oak, overcup oak, tupelo gum, swamp black gum, and cypress.

Tidal marshes in the Chesapeake Bay area vary considerably due to salinity regimes ranging from less than 1 ppt in the upper reaches of the Bay to 30 ppt near the mouth (Lippson 1973). The western shore of the Chesapeake Bay contains water of lower salinities. In this region salt reed-grass is often found bordering streams in the fresher areas, and seashore salt grass is more abundant than salt-meadow cordgrass at higher elevations (Cooper 1969).

Wass (1969) stated that the smooth cordgrass community, as represented by that bordering lower Chesapeake Bay, supports all marsh periwinkles, ribbed mussels, and mud fiddler crabs. The diamond-backed terrapin is the principal reptile. Four species of birds nest in the marsh proper: the clapper rail, Forester's tern, willet, and laughing gull. Many other birds, especially during migration, use the marsh areas. Seventy-three species of birds which are normally associated with water, marsh, and beach habitat were located in the Chincoteague area of the Chesapeake Bay during the Audubon 1968 Christmas count (Plunkett 1969). Raccoons are the most abundant mammal of the salt marsh (Wass 1969).

The fresher salt reed-grass marshes have a lower diversity of fauna than do the smooth cordgrass marshes. Here the red-jointed fiddler crab and a few insects and spiders are the dominant invertebrates. Muskrats and raccoons are the most abundant mammals, along with the mink (Wass 1969). Long-billed marsh wrens, king and clapper rails, and common gallinules nest in this marsh type. Many other birds use these marshes during migration, but not to the extent that the smooth cordgrass marshes are used (Wass 1969).

e. Open-water habitat, Philadelphia and Detroit Districts. Submergent plants such as pondweed and water milfoil are to be expected in the zone which is shallow enough for light to penetrate to the bottom but deep enough that floating-leaved plants such as waterlilies cannot grow and shade them out. In even more shallow zones, emergent plants such as cattails and arrowheads can be found.

94. Alternatives. The alternatives described below represent options available to Districts in the North Atlantic Region. General methodologies to attain desired habitats and biotic components are presented. A biologist and/or soils engineer should be at each site during habitat enhancement activities to refine the methodologies.

95. The target species should be defined, its habitat requirements identified, and suitable vegetative cover, food and water resources, and living space provided. Once these requirements have been met, active habitat management must often be continued to control population levels and ecological succession. In order to select target species, the advice of biologists in the region was sought concerning valuable wildlife species. Their suggestions along with the feasibility of appropriate habitat preparation for the target species were considered in the final selection.

a. Upland habitat. The following game and furbearing animals can benefit most from habitat development on upland portions of disposal areas:

	Page
Mourning dove	C1
Ruffed grouse	C3
Woodcock	C6
Bobwhite	C9
Turkey	C14
Ring-necked pheasant	C17
Canada goose	C25

See the above-listed pages for general habitat requirements and management.

Common reed rapidly colonizes most disposal sites in the North Atlantic Region. It can be of use in desiccating disposal areas by evapo-transpiration. Ecological succession, however, will not readily proceed from this point without some major perturbation. In order to provide habitat other than that of common reed it is necessary to eliminate it. Therefore, the primary habitat maintenance schemes for brackish and freshwater disposal sites require replacement of common reed stands with more desirable species. Herbicide application and some water-level management techniques have been used to remove common reed (Mr. Fred Ferrigno, Personal Communication). Alternatives to herbicide application including burning, harvesting, and trampling vegetation.

Following removal of common reed physical characteristics of the soil should be determined. The soil in this region will probably require a high-level application of lime due to its typical acidic nature and high exchange capacity (Gold 1971). In more brackish or marine disposal sites where organic mud and silt predominate, liming helps prevent a dense layer of clay from forming just beneath the ground surface (Gosselink et al. 1972). Gold (1971) described some problems encountered with excessive zinc in disposal material, which can be compensated for with proper fertilization. If pollutants are a possible constituent of the dredged material, tests should be performed to confine their presence or absence. Care should be taken to insure that desired vegetation will not take up toxic materials from buried soil and render them available for faunal consumption. Periodic checks for pollutants in vegetation should be undertaken where this event is a likelihood.

After the site has been properly prepared, the area can be seeded or sprigged with herbs and grasses or planted with tree seedlings or shrubs, although vegetation may volunteer if sufficient natural seed sources are available in the vicinity. At this point the site may be left unperturbed to undergo natural succession to the desired stage. Any perturbation to the system such as mowing, burning, or further disposal of dredged material would arrest or lengthen the successional process.

b. <u>Halophytic and freshwater wetland habitat</u>. The following game animals may specifically benefit by enhancement schemes on wetland areas of dredged material disposal sites:

	Page
Canada goose	C25
Mallard	C27
Black duck	C29
Wood duck	C31
Muskrat	C33

Many species of waterfowl would find the developed habitat suitable. Those mentioned above have had substantial information generated in the literature concerning their management and are representative of this group of game animals.

Halophytic wetlands will require a tidal flux and may require seeding with appropriate species. High marsh habitats could be created by use of low dikes to allow spring tidal influence and/or allowance of tidal flux by opening flood gates in the confinement.

Freshwater wetlands may be established in fresh or brackish water environments (see Savannah test area). Techniques for this include partitioning disposal areas to allow settling of suspended sediments, and creating depressions and soil characteristics to allow water to pond. A confinement which is to become a freshwater marsh may require flushing with rainwater to reduce salinity where sediment contains salt ions. To allow marsh succession to proceed satisfactorily in disposal sites which are frequently used, compartmentalization will be necessary to prevent successional retardation. Wetlands in freshwater areas would require less partitioning and flushing regimes. Common reed removal may still be necessary and could be accomplished through use of a herbicide. Stocking the site with desired fur-bearers, forage plants, and waterfowl such as commercially available mallards could be done. Vegetation removal through use of herbicide and water-level management may be necessary to maximize waterfowl use. Fur-bearers may also require management. Evaluations should be made to determine best population levels for fur-bearers and to maximize the waterfowl carrying capacity.

c. Open-water habitat. Open-water habitats may be created on confined disposal sites by varying the elevation of the area and/or dikes and by lining the depressed areas with relatively impermeable substrates. Adequate water supply may be obtained from rainfall, diversion of a portion of a nearby water course, or pumping.

Largemouth bass (page C54) and bluegill (page C53) communities are easily established by using proper stocking techniques in newly created ponds. The pond should consist of shallow areas about one m in depth, and at least one deep area in excess of six m. At least 10 percent of the bottom substrate in the shallow areas should provide a firm base for largemouth bass nesting (Curtis 1949, Simon 1951). Sand or gravel would suffice. Bluegill are less restricted in their spawning habits and can nest on various substrates including mud (Calhoun 1966). The introduction of aquatic vegetation would provide a food source and cover for prey organisms. Additional cover consisting of boulders, sunken logs, or other debris would provide additional protection as well as increased surface area for algal production (Reid 1961).

Stocking of largemouth bass at the rate of 100 fry/acre and bluegill at 500 to 1000 fry/acre was recommended by Regier (1963). Planting these fish in spring would allow the best chance for their survival, because during this period the greatest food supply exists. Assistance with stocking is given by many state fisheries departments when public access is allowed to such waters.

After initial stocking, periodic examination and the application of maintenance procedures may be required. A largemouth bass-bluegill community can become imbalanced with an over-abundant bluegill population that retards largemouth bass numbers by preying too heavily on the bass fry. The bluegill population then becomes stunted because of the increased competition for available food and decrease in predation (Calhoun 1966). This can be corrected by several methods, one being the addition of another predator species such as northern pike (K. D. Carlander, Personal Communication). Another method is selected elimination of the overabundant species (Calhoun 1966).

The presence of pollutants in the water and sediments is undesirable as toxic conditions may arise or pollutants may enter the food chain. Covering the sediments with an impermeable layer should isolate them from the biological community. Since plant roots may penetrate to the polluted level, the vegetation should be periodically examined to determine if uptake is occurring.

d. Other habitat. The development of nesting habitat for colonial bird species is often difficult to attain since such habitats often depend on nearby suitable feeding grounds and on the absence of human and tidal intrusion. The development of feeding habitat, on the other hand, is relatively easy to establish for most species.

Nesting habitat requires that adequate feeding grounds be nearby, human intrusions be at a minimum during and just prior to nesting seasons, and the area be close to the coast. Many species require island environments and most need sand for a nesting substrate. Shorebird feeding habitat can be readily created by providing a shallow-water environment. The soil composition is relatively unimportant as long as pollution is not a problem and the sediment will retain water. To discourage significant macrophytic vegetation accumulation, water levels should be varied over a relatively wide range with use of tidal waters or waters from dredged material disposal, or by burning in the winter to kill emergent freshwater vegetation.

Wetland and terrestrial ecological succession should be maintained at its earliest stages for successful shorebird feeding habitats. Aquatic succession from an oligotrophic to eutrophic state can be allowed to proceed unimpeded up to the point where emergent macrophytic vegetation such as cattails, reeds, sedges, and rushes begins significant development.

The best goals for habitat enhancement in this area include shorebird feeding, and gull, tern, skimmer, and wading bird nesting. Wading bird nesting requirements and management schemes are cited on page C35; general shorebird feeding habits, requirements, and habitat creation schemes are listed on page C38. Specific target species which form nesting colonies include:

	Page
Herring gull	C42
Ring-billed gull	C43
Laughing gull	C44
Common tern	C45
Roseate tern	C46
Caspian tern	C47

Gull-billed tern	C48
Royal tern	C49
Forester's tern	C50
Least tern	C51

South Atlantic Region

96. Constraints. Pollution of waters and sediments along the major river systems in the south should be considered in designing viable wildlife enhancement alternatives. Municipal wastes and industrial pollutants which enter the rivers and estuaries are potentially harmful to wildlife, particularly aquatic and wetland species. The Savannah River requires maintenance dredging and the waters of the lower reaches of the river are polluted. These problems are most acute in impoundments where leachates of sediments can accumulate. Legal constraints, besides those mentioned in the EPA, are not prominent in much of this region.

97. Succession patterns. Discussions of successional stages expected in the South Atlantic Region concentrate on areas studied during the field phase of this investigation.

a. Upland habitat, Charleston and Savannah Districts. The dominant vegetation type for the Charleston District is southeastern forest, dominated by cypress and tupelo or various oaks (Braun 1950). This climax is often modified by edaphic and other environmental factors to produce a situation dominated by species other than the hardwoods.

The herbaceous stage is vegetated principally by grasses, broom sedge, goldenrod, aster, and pokeweed. Numerous animals feed in this habitat including mourning doves, bobwhite, savannah sparrows, red-winged blackbirds, eastern meadowlarks, eastern cottontails, and white-footed mice (Martin et al. 1951).

The herbaceous stage gradually gives way to the shrub stage, which is dominated by myrtle, groundsel, black cherry, sumac, and blackberry and some herbs from the previous stage. The fauna that feed among these shrub species include the bobwhite, mourning dove, mockingbird, sparrows, gray catbird, white-tailed deer, white-footed mouse, and eastern cottontail.

Light-tolerant tree species invade the habitat and produce an evergreen stage. The principal vegetative components are loblolly and long leaf pines, black cherry, and shrubs of the previous stage. Animals which feed in this habitat are bobwhite, Bachman's sparrow, Carolina chickadee, nuthatch, fox squirrel, and gray squirrel.

The climax forest follows the young hardwoods and consists primarily of oak, hickory, and pine or cypress and tupelo. Numerous animals, especially game species, spend large amounts of time in these woods while feeding in shrub and field areas. The blue jay, red-bellied woodpecker, tufted titmouse, eastern chipmunk, white-footed mouse, and raccoon (Martin et al. 1951) feed on animal and plant matter produced in this environment.

b. Wetland habitat, Charleston and Savannah Districts. The vegetative cover of an inland shallow freshwater marsh in this region is principally arrowhead, pickerelweed, cattail, and smartweed (Shaw and Fredine 1956). These marshes in conjunction with inland deep freshwater marshes are used as feeding and nesting areas by waterfowl but only for nesting in northern portions of this region (Shaw and Fredine 1956). Other animals which use the food resources located in these areas are the white-tailed deer, mink, muskrat, raccoon (Martin et al. 1951), mud turtle, yellow-bellied turtle, water snake, cottonmouth, spring peeper, green treefrog, pig frog, and bullfrog (Conant 1958).

Shrub swamp areas are vegetated primarily by willow and buttonbush. These marshes are considered less valuable for waterfowl and are used only to a limited extent for feeding and nesting (Shaw and Fredine 1956). Other animals, including white-tailed deer, beavers, raccoons, muskrats, and minks, use the food produced by the plants of the shrub swamp.

Wooded swamps contain waterlogged soils to within an inch of the surface during the growing season and are often covered by as much as a foot of water. Cypress, tupelo, gum, and buttonbush make up the major vegetative components. As with shrub swamps, waterfowl usage is low. Those animals likely to use wooded swamps include wood ducks, woodcocks, white-tailed deer, beavers, minks, raccoons, water snakes, cottonmouths, and frogs.

From the Chesapeake Bay southward along the Atlantic coast and Gulf coast are found the best developed salt marshes in the United States. At the southern limit, these marshes grade into mangrove swamps of south Florida. Even though these marshes have similar characteristics, some variation by region can be recognized (Cooper 1969).

Brackish sounds located behind the outer banks of North Carolina south to Cape Lookout are fringed with irregularly flooded marshes. The low tidal influence of the sounds limits the growth of smooth cordgrass to a fringe along water courses. At an elevation just above mean high water, dense stands of black rush are found. In other areas saltmeadow cordgrass develops behind the smooth cordgrass usually at slightly higher elevations than the black rush (Cooper 1969).

From Cape Lookout south to Jacksonville, Florida, occur some of the best developed salt marshes in the United States. The characteristic feature of these marshes is the vast expanses of smooth cordgrass rooted in soft gray sediments. Again, elevation differences result in zonation of plant communities. There is an area along the creek banks, exposed at low tide, which is devoid of higher vegetation. Above this zone from about mean high tide to the crest of the levee is a zone of optimum growth for smooth cordgrass. Here a tall form of the grass grows, often reaching two m in height. Along the top of the levee, medium smooth cordgrass between one and two m is found. Away from the creeks a short form of smooth cordgrass grows. At higher elevation the smooth cordgrass is often mixed with glasswort seashore salt grass and sea-lavender. At slightly higher elevations, patches of pure stands of black rush are found. Above this zone is often found saltmeadow cordgrass (Teal 1962).

The most abundant herbivorous insect in the salt marsh is the salt marsh grasshopper, which feeds directly on living smooth cordgrass. Detritus feeders include three species of fiddler crabs, ribbed mussels, and salt marsh periwinkles as well as many annelid worms, oligochaetes, and insect larvae. These are preyed upon by the abundant mud crabs, clapper rails, and raccoons (Teal 1962).

c. Open-water habitat, Charleston and Savannah Districts. No intensive study was made of open-water habitats for the South Atlantic Region. Submergent plants, such as pondweed and water milfoil, are to be expected in the zone which is shallow enough for light to penetrate to the bottom but deep enough that floating-leaved plants, such as water-lilies, cannot grow and shade them out. In even more shallow zones, emergent plants such as cattails and arrowheads can be found.

98. Alternatives. The alternatives described below represent options available to Districts in the South Atlantic Region. General methodologies to successfully attain desired habitats and biotic components are presented. A biologist and/or soils engineer should be at each site during habitat enhancement activities to refine the methodologies.

99. The target species should be defined, its habitat requirements identified, and suitable vegetative cover, food and water resources, and living space provided. Once these requirements have been met, active habitat management must often be continued to control population levels and ecological succession. The advice of biologists in the region was sought concerning valuable wildlife species.

a. Upland habitat. The following game and fur-bearing animals can benefit most from habitat development on upland portions of disposal areas:

	Page
Mourning dove	C1
Woodcock	C6
Bobwhite	C9
Turkey	C14
Canada goose	C25
White-tailed deer	C19
Eastern cottontail	C22

See the above-listed pages for general habitat requirements and management.

In order to provide suitable upland habitats for the target species, certain manipulations may be necessary. Compartmentalizing or partitioning sites and rotating disposal locations within sites should be considered for habitat beyond the earliest successional stages (see experimental format for MRGO and Savannah test areas as examples). In large confined disposal areas, particularly where disposal is frequent, mounds can be created which are at an elevation above the disposed dredged material. These will serve as seed sources to speed establishment of vegetation after disposal.

Once the dredged material is relatively dry, physical characteristics should be determined. Soil pH near neutrality is desirable; application of lime will be needed if the soil is acidic. In more brackish or marine disposal sites where organic mud and silt predominate, liming helps prevent a dense layer of clay from forming just beneath the ground surface (Gosselink et al. 1972). Gold (1971) described some problems encountered with excesses in zinc in disposal materials, which can be compensated for with proper chemical treatment. If pollutants are a possible constituent of the dredged material, tests should be performed to confirm their presence or absence. Attention should be given to insure that desired vegetation will not take up toxic materials from buried soil and render them available for faunal consumption. Periodic checks for pollutants in vegetation should be undertaken where this event is a likelihood.

After the site has been properly prepared, the area can be seeded or sprigged with herbs and grasses, or planted with tree seedlings or shrubs, although vegetation may volunteer if sufficient natural seed sources are available in the vicinity. At this point the site may be left unperturbed to undergo natural succession to the desired stage.

b. Halophytic and freshwater wetland habitat. The following game animals may specifically benefit by enhancement schemes on wetland areas of dredged material disposal sites:

	Page
Canada goose	C25
Mallard	C27
Black duck	C29
Wood duck	C31
Muskrat	C33

Many species of waterfowl would find the developed habitat suitable. Those mentioned above have had substantial information generated in the literature concerning their management and are representative of this group of game animals. Halophytic wetlands will require a tidal flux and may require seeding with appropriate species. High marsh habitats could be created by use of low dikes (to allow spring tidal influence) and/or allowance of tidal flux by opening flood gates in the confinement.

Freshwater wetlands may be established in fresh or brackish water environments (see Savannah test area). Techniques for this include partitioning disposal areas to allow fine suspended sediments to settle and water to stand in shallow depths. A confinement which is to become a freshwater marsh may require flushing with rainwater to reduce salinity where sediment contains salt ions. To allow marsh succession to proceed satisfactorily in disposal sites which are frequently used, compartmentalization will be necessary to prevent successional retardation. Wetlands in freshwater areas would require less flushing. Stocking the site with desired fur-bearers, forage plants, and waterfowl such as commercially available mallards could be done. Vegetation removal through use of herbicides and water-level management may be necessary to maximize waterfowl use. Fur-bearers may also require management through trapping. Studies should be made to determine best population levels for fur-bearers and to maximize the waterfowl carrying capacity.

c. Open-water habitat. Open-water habitats may be created on confined disposal sites by varying the elevation of the area and/or dikes and by lining the depressed areas with relatively impermeable materials. Adequate water supply may be obtained from rainfall, diversion of a portion of a nearby water course, or pumping.

A channel catfish, largemouth bass, and bluegill community is easily established by using proper stocking techniques in a shallow water body.

The water body should consist of shallow areas approximately one m in depth, and at least one deep area of about three m. At least 10 percent of the bottom substrate, sand or gravel, in the shallow areas should provide a firm base for largemouth bass nesting (Curtis 1949, Simon 1951). Channel catfish require protected nest sites. Artificial nest materials that have been commonly used are nail kegs, metal milk or cream cans, and crockery jars (Stickney 1970). Bluegill are less restricted in their spawning habits and can nest on various substrates including mud (Calhoun 1966). The introduction of aquatic vegetation would provide a food source and cover for prey organisms. However, channel catfish seldom live in dense aquatic vegetation (Trautman 1957, Marzolf 1957). Predaceous insects may reduce survival of the catfish fry in such habitats. Additional cover consisting of boulders, sunken logs, or other debris would provide additional protection as well as increased surface area for algal production (Reid 1961).

Stocking of largemouth bass at the rate of 100 fry/acre and bluegill at 500 to 1000 fry/acre was recommended by Regier (1963), while Finnel and Jenkins (1954) suggested 50 channel catfish fry per acre. Assistance with stocking is given by many state fisheries departments when public access is available to such waters.

After initial stocking, periodic examination and the application of maintenance procedures may be required. This community can become imbalanced with disproportionate ratios between fish populations. Methods to correct this situation include the stocking of additional fish of the depleted populations and the selected elimination of the over-abundant species (Calhoun 1966).

The presence of pollutants in the water and sediments is undesirable as toxic conditions may arise or pollutants may enter the food chain. Covering the sediments with an impermeable layer should isolate them from the biological community. Since plant roots may penetrate to the polluted level, vegetation should be periodically examined to determine if uptake is occurring.

d. Other habitat. The best goals for habitat enhancement for other species in this area include shorebird feeding areas and American avocet, tern, black skimmer, black-necked stilt, and wading bird nesting areas.

The development of nesting habitat for colonial bird species is often difficult to attain since habitats are often dependent on nearby suitable feeding grounds and on the absence of human and tidal intrusion. Feeding habitat development, on the other hand, is relatively easy to obtain.

Nesting habitat requires that adequate feeding grounds be nearby; human intrusion be at a minimum during and just prior to nesting seasons; and the area be close to the coast. Shorebird feeding habitat can be readily created by providing a shallow-water environment. The soil composition is relatively unimportant as long as pollution is not a problem and sediments will hold water. To discourage significant macrophytic vegetation accumulation, water levels should be varied over a relatively wide range with use of tidal waters or waters from dredged material disposal, and burning should be carried out in the winter to kill emergent freshwater vegetation. Further refinements to development and maintenance of shorebird feeding are discussed on page C38.

Wading bird nesting requirements and management schemes are cited on page C35. Miscellaneous shorebird feeding habitat requirements and habitat development schemes are listed on page C38. Specific target species which form nesting colonies include:

	Page
Caspian tern	C47
Gull-billed tern	C48
Royal tern	C49
Least tern	C51

Gulf Coast Region

100. Constraints. Municipal wastes and industrial pollutants which enter the Mississippi River, the MRGO, and

estuaries are potentially harmful to wildlife, especially aquatic and wetland species. Chemical and bacterial contamination should be anticipated wherever dredged water courses are used by a significant number of industries and municipalities. Legal constraints are not prominent in the region nor is scarcity of disposal sites a severe constraint.

101. Successional patterns. Discussion of successional stages to be expected in the Gulf Coast Region concentrates on areas studied during the field phase of this investigation.

a. Upland habitat, New Orleans District. The vegetation type of the New Orleans District is southeastern evergreen forest dominated by beech, sweetgum, magnolia, pine, and oak (Braun 1950). Floodplain forests are dominated by oak, tupelo, and bald cypress. Forests are often modified by edaphic and other environmental factors to produce species associations other than that given above.

The herbaceous stage is vegetated principally by grasses, broom sedge, goldenrod, aster, and pokeweed. Numerous animals including mourning dove, bobwhite, savannah sparrow, red-winged blackbird, eastern meadowlark, eastern cottontail, and white-footed mouse forage in this highly productive area (Martin et al. 1951).

The herbaceous stage gradually gives way to the shrub stage which is dominated by myrtle, groundsel, blackberry, and some herbs from the previous stage. Examples of animals that feed on these shrub species are the bobwhite, mourning dove, mockingbird, sparrows, gray catbirds, white-tailed deer, white-footed mouse, and eastern cottontails (Martin et al. 1951).

Light-tolerant tree species invade the shrub habitat and produce an evergreen stage. The principal vegetative components are loblolly and long leaf pines, and shrubs of the previous stage. Examples of animals which feed on seeds of these species are bobwhite, Bachman's sparrows, Carolina chickadees, nuthatches, fox squirrels, and gray squirrels.

Climax forest of oaks and hickories succeeds the young hardwoods. Numerous animals, especially game species, spend large amounts of time in these woods, using them for food and shelter. Red-cockaded woodpecker, tufted titmouse, brown-headed nuthatch, eastern chipmunk, white-footed mouse, fox squirrel, gray squirrel, beaver, and black bear are the major consumers of the seeds and bark and associated insects of these tree species (Martin et al. 1951).

b. <u>Wetland habitat, New Orleans District</u>. The vegetation cover of an inland shallow freshwater marsh in this region is principally arrowhead, pickerelweed, cattail, and smartweed (Shaw and Fredine 1956). These marshes, in conjunction with inland deep freshwater marshes, are used as feeding and nesting areas by waterfowl (Shaw and Fredine 1956). Other animals which use the food resources in these areas are white-tailed deer, minks, muskrats, and raccoons (Martin et al. 1951), red-eared turtles, chicken turtles, water snakes, spring peepers, cricket frogs, and bullfrogs (Conant 1958).

Shrub swamp areas are vegetated mainly by swamp privet and buttonbush. These marshes are considered less valuable for waterfowl and are used only to a limited extent for feeding and nesting (Shaw and Fredine 1956). Other animals including white-tailed deer, beaver, raccoon, muskrat, and mink use the food materials produced by the plants of the shrub swamp.

Wooded swamps contain waterlogged soils to within an inch of the surface during the growing season and are often covered by as much as a foot of water. Cypress, tupelo, gum, and buttonbush make up the major vegetative components. As with shrub swamps, the waterfowl usage is low. Those animals likely to use wooded swamps include wood duck, woodcock, white-tailed deer, beaver, mink, raccoon, cottonmouth, pig frog, and bullfrog.

Gulf coast salt marshes have similar plant species as found in the South Atlantic marshes; however, the widths of the marsh zones may differ. On the Florida Gulf Coast from Cedar Key to Appalachee Bay, black rush is the dominant marsh type. From Appalachee Bay westward to Pensacola, there is little marsh, with the shore zone consisting mainly of open lagoons and estuaries. West of

Pensacola to the mouth of the Mississippi River, black rush again predominates with some smooth cordgrass development along sheltered beaches. The best developed marsh of the Gulf coast is near the mouth of the Mississippi River. Here smooth cordgrass dominates in regularly flooded saline areas. In areas of lower salinity, saltmeadow cordgrass, seashore salt grass, and black rush are found. A zone of salt reed-grass and common reed often occurs near high ground (Cooper 1969). Marshes similar to those in Louisiana, also occur in eastern Texas.

The faunal components of the South Atlantic Gulf coast zones are similar. Because the South Atlantic marshes have been studied in greatest detail, those inhabitants will be presented here as representative assemblages of both zones. The most abundant herbivorous insect is the salt marsh grasshopper, which feeds directly on living smooth cordgrass. Detritus feeders include species of fiddler crabs, mud crabs, and salt marsh periwinkles, as well as many annelid worms, oligochaetes, and insect larvae. These are preyed upon by the abundant mud crab and raccoon (Teal 1962).

c. Open-water habitat, New Orleans District. Submergent plants, such as pondweed and water milfoil, are to be expected in the zone of ponds which are shallow enough for light to penetrate to the bottom but deep enough that floating-leaved plants, such as waterlilies, cannot grow and shade them out. In even more shallow zones, emergent plants such as cattails and arrowhead can be found. The fish species too may change with succession from populations of minnows and bluegill to those dominated by suckers and bullhead.

102. Alternatives. The alternatives described below present options available to Districts in the Gulf Coast Region. General methodologies to successfully attain desired habitats and biotic components are presented. A biologist and/or soils engineer should be at each site during habitat enhancement activities to refine the methodologies.

103. The target species should be defined, its habitat requirements identified, and suitable vegetative cover, food and water resources, and living space provided. Once these requirements have been met, active habitat management must often be continued to control population levels and ecological succession. The advice of biologists in the region was sought concerning valuable wildlife species.

a. Upland habitat. The following game and fur-bearing animals can benefit most from habitat development on upland portions of disposal areas:

	Page
Mourning dove	C1
Woodcock	C6
Bobwhite	C9
Turkey	C14

	Page
Canada goose	C25
White-tailed deer	C19
Eastern cottontail	C22
Swamp rabbit	C58
Marsh rabbit	C59

See the above-listed pages for general habitat requirements and management.

In order to provide the appropriate upland habitats for the target species, certain manipulations may be necessary. Compartmentalizing or partitioning sites and rotating disposal locations within sites should be considered for habitat beyond the earliest successional stages (see experimental format for MRGO and Savannah test areas as examples). In large confined disposal areas, particularly where disposal is frequent, mounds can be created which are at an elevation above the disposed dredged material. These will serve as seed sources to speed establishment of vegetation after disposal.

Once the dredged material is relatively dry, physical characteristics should be determined. Soil pH near neutrality is desirable; application of lime will be needed if the soil is acidic or possesses a high exchange capacity (Gold 1971). In more brackish or marine disposal sites where organic mud and silt predominate, liming helps prevent a dense layer of clay from forming just beneath the ground surface (Gosselink et al. 1972). Nutrient enhancement by fertilization may be required. Soil drainage characteristics may need to be modified according to desired habitat. If pollutants are a possible constituent of the dredged material, tests should be performed to confirm their presence or absence. Attention should be paid to insure that desired vegetation will not take up toxic materials from buried soil and render them available for faunal consumption. Periodic checks for pollutants in vegetation should be undertaken where this event is a likelihood.

After the site has been properly prepared, the area can be seeded or sprigged with herbs and grasses, or vegetation may volunteer if sufficient natural seed sources are available in the vicinity. At this point the site may be left unperturbed to undergo natural succession to the desired stage. Any perturbation to the system such as mowing, burning, and further disposal of dredged material would arrest or lengthen the successional process.

b. <u>Halophytic and freshwater wetland habitat</u>. The following game animals may specifically benefit by enhancement schemes on wetland areas of dredged material disposal sites:

	Page
Canada goose	C25
Mallard	C27
Black duck	C29

	Page
Shoveler	C66
Wood duck	C31
Muskrat	C33

Many species of waterfowl would find the developed habitat suitable. Those mentioned above have had substantial information generated in the literature concerning their management and are representative of this group of game animals.

Halophytic wetlands will require a tidal flux and may require seeding with appropriate species. High marsh habitats could be created by use of low dikes (to allow spring tidal influence) and/or exposure to tidal flux by opening small holes in the confinement.

Freshwater wetlands may be established in presently freshwater or brackish water environments (see Savannah test area for details, page 172). Techniques for this include partitioning disposal areas to allow settling of suspended sediments, and creating depressions and soil characteristics to allow water to pond. A confinement which is to become a freshwater marsh may require flushing with rainwater to reduce salinity where sediment contains salt ions. To allow marsh succession to proceed to the desired stage in disposal sites which are frequently used, compartmentalization will be necessary to prevent successional retardation. Wetlands in freshwater areas would require less flushing than in saline areas. Stocking the site with desired fur-bearers, forage plants, marsh grasses, and waterfowl such as commercially available mallards could be done. Vegetation removal through use of herbicides and water-level management may be necessary to maximize waterfowl use. Fur-bearers may also require management. Studies should be made to determine best population levels for fur-bearers and to maximize the carrying capacity for waterfowl.

c. Open-water habitat. Open-water habitats may be created on confined disposal sites by varying the elevation of the area and/or dikes and by lining the depressed areas with relatively impermeable substrates. Adequate water supply may be obtained from rainfall, diversion of a portion of a nearby water course, or pumping.

A channel catfish, largemouth bass, and bluegill community is easily established by using proper stocking techniques in a shallow-water pond.

The pond should consist of shallow areas one m in depth, and at least one deep area of about three m. At least 10 percent of the bottom substrate, sand or gravel, in the shallow areas should provide a firm base for largemouth bass nesting (Curtis 1949, Simon 1951). Channel catfish require protected nest sites. Artificial nest materials that have been commonly used are nail kegs, metal milk or cream cans, and crockery jars (Stickney 1970). Bluegill are less restricted in their spawning habits and can nest on various substrates including mud (Calhoun 1966). The introduction of aquatic vegetation would provide a food source and cover for prey organisms. However, channel catfish seldom live in dense aquatic vegetation (Trautman 1957, Marzolf 1957). Predaceous insects may reduce survival of catfish fry in such habitats. Additional cover consisting of boulders, sunken logs, or other debris would provide additional protection as well as increased surface area for algal production (Reid 1961).

Stocking of largemouth bass at the rate of 100 fry/acre and bluegill at 500 to 1000 fry/acre was recommended by Regier (1963), while Finnel and Jenkins (1954) suggested 50 channel catfish fry per acre. Assistance with stocking is given by many state fisheries departments when public access is available to such waters.

After initial stocking, periodic examination and the application of maintenance procedures may be required. This community can become imbalanced with disproportionate ratios between fish populations. Methods to correct this situation include the stocking of additional fish of the depleted populations and the selected elimination of the over-abundant species (Calhoun 1966).

The presence of pollutants in the water and sediments is undesirable as toxic conditions may arise or pollutants may enter the food chain. Covering the sediments with an impermeable layer should isolate them from the biological community. Since plant roots may penetrate to the polluted level, vegetation should be periodically examined to determine if uptake is occurring.

d. Other habitat. The best goals for habitat enhancement in this area include shorebird feeding areas and nesting areas for American avocet, terns, black skimmer, black-necked stilt, and wading birds. One of the most difficult of habitat-usage goals to attain successfully is the creation of nesting habitat for colonial bird species. Feeding habitat creation, on the other hand, is relatively easy to obtain. Nesting habitat requires that adequate feeding grounds be nearby; human intrusion be at a minimum during and just prior to nesting seasons; and the area be close to the coast.

Shorebird feeding habitat can be readily created by providing a shallow-water environment. The soil composition is relatively unimportant as long as pollution is not a problem and sediments will hold water. To discourage significant macrophytic vegetation accumulation, water levels should be varied over a relatively wide range with use of tidal waters or waters from dredged material disposal, and by burning in the winter to kill emergent freshwater vegetation.

Wetland and terrestrial ecological succession should be maintained at its earliest stages for successful shorebird feeding habitats. Aquatic succession from an oligotrophic to eutrophic state can be allowed to proceed unimpeded up to the point where emergent macrophytic vegetation such as cattails, reeds, sedges, and rushes begin significant development.

Habitats for threatened species are best developed in areas that are away from human interference and that possess optimum feeding and nesting conditions. Many areas along waterways in the Gulf Region are relatively remote and provide adequate feeding habitat for the osprey (page C60). However, there is often an absence of trees near the waterways which are suitable for nesting. Artificial nesting structures can be constructed (page C60).

Wading bird nesting and food requirements and management schemes are cited on page C35. Miscellaneous shorebird feeding habitats, food requirements, and habitat creation schemes are listed on page C38. Specific target species which form nesting colonies include:

	Page
Gull-billed tern	C48
Royal tern	C49
Least tern	C51

Pacific Coast Region

104. Constraints. Pollution levels of waters and sediments of Coos Bay and estuaries should be considered in designing viable wildlife enhancement alternatives. Municipal

waste and industrial pollutants entering the bay, rivers, and estuaries are potentially harmful to wildlife, particularly aquatic and wetland species. The problems are most acute in impoundments where leachates of sediments can accumulate. As water quality is improved through better treatment procedures, pollution characteristics of maintenance dredged materials should similarly improve. However, initial dredging may still mix and disturb polluted sediments which were buried prior to water-quality improvements. Legal constraints in this region besides the EPA criteria are few.

105. Successional patterns. The discussion of successional patterns to be expected in the Pacific Region concentrates on the central portion of the Pacific coastal area where these studies were undertaken.

a. Upland habitats, Portland District. The coastal portion of the Portland District is in a vegetation zone dominated by sitka spruce, western hemlock, western red cedar, douglas fir, and grand fir (Franklin and Dyrness 1973). This climax is often modified by edaphic and other environmental factors to produce a situation dominated by species other than evergreens.

The herbaceous successional stage is dominated by grasses and forbs, such as Italian rye grass, velvet grass, sedges, and clover. Fringillids and ring-necked pheasant are examples of species using this habitat (Martin el al. 1951). Habitats vegetated with herbs succeed into brush or shrub habitats including chaparral broom and dogwoods. This brush or shrub stage then succeeds toward the climax evergreen state.

b. Wetland habitat, Portland District. The vegetation cover of shallow freshwater marshes in this region is made up principally of pondweed, widgeon grass, and smartweed. Waterfowl make considerable use of such habitats.

Shrub swamps are vegetated by willows. They are considered less valuable then herbaceous-dominated marshes for waterfowl nesting (Shaw and Fredine 1956). Medium-sized mammals such as opossum and raccoon, however, will use the food materials produced by plants of the shrub swamp.

Wooded wetland areas dominated by western hemlock, red alder, and willow represent mature wetland successional stages (Shaw and Fredine 1956). Wood ducks nest in such areas, as well as warblers, woodpeckers, and a variety of small mammals and other birds.

There are few salt marshes along the Pacific coast of the United States. Most are located in small embayments where rivers have deposited sediments. The marshes which exist in southern California exhibit zonation in similar fashion to those of the east coast. Mud flats are located between the water's edge and a narrow zone of California cordgrass. Above the cordgrass zone is a large zone of glasswort and saltwort. Landward of this zone is an area still dominated by glasswort mixed with many other species including jaumea, salt grass, and frankenia (Cooper 1969). Marshes to the north in San Francisco Bay are similar but lack saltwort. Along the Washington and Oregon coasts, there is little marsh development, and that present has been little studied.

106. Alternatives. The alternatives described below represent options available to Districts in the Pacific Coast Region. General methodologies to successfully attain desired habitats and biotic components are presented. A geologist and/or soils engineer should be at each site during habitat enhancement activities to refine the methodologies.

107. The target species should be defined, its habitat requirements identified, and suitable vegetative cover, food and water resources, and living space provided. Once these requirements have been met, active habitat management must be continued to control population levels and ecological succession. In order to select target species, the advice of biologists in the region was sought concerning valuable wildlife species. Their suggestions along with the feasibility of appropriate habitat preparation for the species were considered in the final selections.

a. Upland habitat. The following upland game and fur-bearing animals can benefit most from habitat development on upland portions of disposal areas:

	Page
Common snipe	C61
Ruffed grouse	C3
Pintail	C65
American wigeon	C64
Black-tailed deer	C62
Brush rabbit	C63

See the above-listed pages for general habitat requirements and management.

In order to provide the appropriate upland habitats for the target species, certain manipulations may be necessary. Compartmentalizing or partitioning sites and rotating disposal locations within sites should be considered for habitat beyond the earliest successional stages (see experimental format for Grassy Island, MRGO, and Savannah test areas as examples). In large confined disposal areas, particularly where disposal is frequent, mounds can be created which are at an elevation above the disposed dredged material. These will serve as seed sources to speed establishment of vegetation after disposal.

Once the dredged material is relatively dry, physical characteristics should be determined. Soil pH near neutrality is desirable; application of lime will be needed if the soil is acidic or possesses a high exchange capacity (Gold 1971). In more brackish or marine disposal sites where organic mud and silt predominate, liming helps prevent a dense layer of clay from forming just beneath the ground surface (Gosselink et al. 1972). Nutrient enhancement by fertilization may be required. Soil drainage characteristics may need to be modified according to desired habitat. In addition if pollutants are a possible constituent of the dredged material, tests should be performed to confirm their presence or absence. Attention should be paid to ensure that desired vegetation will not take up toxic materials from buried soil and render them available for faunal consumption. Periodic checks for pollutants in vegetation should be undertaken where this event is a likelihood.

After the site has been properly prepared, the area can be seeded or sprigged with herbs and grasses or planted with tree seedlings or shrubs although vegetation may volunteer if sufficient natural seed sources are available in the vicinity. At this point the site may be left unperturbed to undergo natural succession to the desired stage or planting of corn, millet, or other agricultural crops will enhance the site for those species preferring early successional habitats, and it will help prepare the soil for natural vegetation to develop.

b. <u>Freshwater wetland habitats</u>. The following game animals may specifically benefit by enhancement schemes on dredged material disposal sites:

	Page
Pintail	C65
American wigeon	C64
Mallard	C27

A multitude of waterfowl would probably use habitat generated for these species. Those mentioned above have had substantial information published concerning their management and are representative of this group of game animals.

Halophytic wetlands will require a tidal flux and may require seeding with appropriate species. High marsh habitats could be created by use of low dikes to allow spring tide influence and/or allowance of tidal flux by opening floodgates in the confinement dikes.

Freshwater wetlands may be established in presently freshwater or brackish water environments (see Savannah test area, and Coos Bay, Upper Island, pages 172 and 178, for details). These techniques involve partitioning disposal areas to allow settling of suspended sediments and creating depressions and soil characteristics to allow water to stand in shallow depths. A confinement which is to become a freshwater wetland may require flushing with rainwater to reduce salinity where sediment contains salt ions. To allow marsh succession to proceed satisfactorily in disposal sites which are frequently used, compartmentalization will be necessary to prevent successional retardation. Wetlands in freshwater areas would require less flushing. Stocking the site with desired waterfowl such as mallard could be done. Vegetation removal through herbicide usage and water-level management may be necessary to maximize waterfowl use. Fur-bearers may also require management.

c. Other habitat. Shorebirds and wading birds are nongame species which will benefit by providing shallow-water environments for feeding. The bottom sediments are relatively unimportant as long as pollution is not a problem and they will hold water. To discourage macrophytic vegetation accumulation, water levels should be varied over a relatively wide range with use of tidal waters and waters from dredged material disposal or by burning in the winter to kill emergent vegetation.

PART IV: POTENTIAL TEST SITES

Objectives

108. The proposed test procedure and selection of representative sites or alternatives were designed to gain the maximum amount of test information that would be applicable on a regional basis. Additionally sites were chosen which were large enough to allow several manipulative operations to be tested.

Site Selection

109. The five sites chosen for experimental habitat manipulation are:

Grassy Island	-	Great Lakes Region
Pedricktown-Penns Grove	-	North Atlantic Region
No. 2 Savannah	-	South Atlantic Region
Station 41 (MRGO)	-	Gulf Coast Region
Upper Island, Coos Bay	-	Pacific Coast Region

110. An evaluation of 13 factors (Table 3) served as a tool in site selection. Judgement of the biologist most familiar with site conditions was used in ranking the 13 factors on a scale of 1 to 3, 3 being optimum. No weighting of the subjectively assigned ranks occurred until final selection between sites, when the summation of the ranks was equal or nearly equal. This meant that some sites, in the Great Lakes Region for example, with nearly equal sums in the

TABLE 3

SITE EVALUATION MATRIX

	Great Lakes Region			North Atlantic Region		
	Riverside	Grassy Island	Tennessee Chute	Dismal Swamp	Pedricktown-Penns Grove	Penns Neck
Legal, economic, and other constraints	1	3	3	1	3	3
Potential for development of flora	2	3	1	2	3	3
Present vegetation succession and diversity	2	1	3	2	2	1
Potential for rare, endangered or uncommon species habitat	2	2	2	3	3	3
Suitability as a test site	1	1	1	3	3	3
Potential for on-site wildlife habitat enhancement alternatives	2	3	1	1	3	3
Potential for diversifying the habitat	3	3	3	3	3	3
Access	3	1	2	3	3	3
Potential variation of types of dredged material	3	2	2	3	2	2
Present animal use	2	3	2	3	2	1
Productivity of the present habitat	1	1	3	2	2	1
Potential for future disposal within three years	1	3	2	1	3	2
Pollution problems with dredged material	3	3	3	1	3	3
SUMMATION OF RANKINGS	26	29	28	28	35	31

Key to value of rank: 1 = poor
2 = neutral
3 = optimum

TABLE 3 (continued)

SITE EVALUATION MATRIX

	South Atlantic Region			Gulf Coast Region		
	Drum Island	No. 2 Savannah	Oyster Bed Island	MRGO Sta. 23.6	MRGO Sta. 41	MRGO Sta. 42
Legal, economic, and other constraints	2	3	2	2	3	1
Potential for development of flora	2	1	2	3	3	3
Present vegetation succession and diversity	3	2	1	2	1	2
Potential for rare, endangered or uncommon species habitat	2	3	3	2	2	2
Suitability as a test site	1	3	3	1	3	2
Potential for on-site widlife habitat enhancement alternatives	2	1	1	1	3	2
Potential for diversifying the habitat	2	1	1	2	2	2
Access	2	3	1	1	3	2
Potential variation of types of dredged material	3	2	2	2	2	2
Present animal use	2	3	3	2	1	3
Productivity of the present habitat	2	1	1	2	1	3
Potential for future disposal within three years	3	3	3	2	3	2
Pollution problems with dredged material	2	3	2	1	1	1
SUMMATION OF RANKINGS	28	29	25	23	28	27

Key to value of rank: 1 = poor
2 = neutral
3 = optimum

TABLE 3 (concluded)

SITE EVALUATION MATRIX

	Pacific Coast Region		
	Coos Bay Upper Island	Coos Bay Middle Island	Coos Bay Lower Island
Legal, economic, and other constraints	3	3	3
Potential for development of flora	3	2	1
Present vegetation succession and diversity	3	2	1
Potential for rare, endangered or uncommon species habitat	3	3	3
Suitability as a test site	3	1	2
Potential for on-site wildlife habitat enhancement alternatives	3	1	2
Potential for diversifying the habitat	3	2	2
Access	2	2	2
Potential variation of types of dredged material	1	1	1
Present animal use	3	2	1
Productivity of the present habitat	3	2	1
Potential for future disposal within three years	3	3	3
Pollution problems with dredged material	1	2	3
SUMMATION OF RANKINGS	34	26	25

Key to value of rank: 1 = poor
2 = neutral
3 = optimum

ranking, could not be clearly signaled out as optimum test areas. The final selection was made with cognizance of the field study results.

Constraints

111. A major constraint is the necessity of accommodating wildlife management techniques around current disposal practices. Aquaculture was not considered a feasible alternative for the confined sites reviewed during this study. The intensive control procedures necessary for successful aquaculture and the anticipated water quality and pollutant problems were the major reasons this alternative was abandoned. The temporal framework of the proposed experimental program prevents development of certain habitats such as mature or even immature wooded stands.

112. Disposal of dredged material on Grassy Island is by privilege of the City of Wyandotte, Michigan, which claims riparian rights to the island. The Corps does not expect to use the site for disposal after the next three years. At that time the island will revert to the City which has tentative recreational plans for it (Mr. D. Billmeyer, Personal Communication). The economic constraints of initiating the proposed alternatives for Grassy Island would be the construction of internal dikes and spillways as shown in Figure 15. These cost estimates would be on the order of $8,000 to $10,000 and include mainly mobilization, use of a dragline and bulldozer, and supervisory labor.

113. The Federal Government has free title to the Pedricktown-Penns Grove site (Figure 21). Therefore, the only constraints to development involve applicable standards for water quality. To date, no opposition has been made to the Corps disposal operations at the site (Mr. H. Griffith, Personal Communication). No economic costs of major proportions would be incurred from implementing the proposed enhancement alternatives.

114. The Corps has perpetual easements for several tracts of the No. 2 Savannah site (Figure 26). Other tracts of the site are owned privately or by the State of Georgia. In all cases, the duration of easements now in effect extends beyond the next three years. One form of constraint to development of this site involves the local mosquito control commission which now requires the Corps to keep the site covered with water (Mr. W. Clarkson, Personal Cummunication). Estimated economic costs, a possible constraint to developing the proposed alternatives for No. 2 Savannah, should be on the order of $25,000 to $27,000. Equipment such as a dragline and bulldozer, control gates, and labor are the major cost items.

115. Station 41 along the MRGO (Figure 35) has no constraints regarding ownership. The MRGO is a relatively new channel (1963) and the Board of Commissioners of the Port of New Orleans still has jurisdiction of the land. The only constraint in operations is that the disposal area

has to be diked and the surface water returned via ditches to the MRGO (Mr. C. J. Nettles, Personal Communication). Economic costs, perhaps on the order of $10,000 to $12,000, would be involved for development of Station 41 alternatives. The Port Authority of Coos Bay, Oregon, furnishes the right for dredged material desposal on the Upper Island of Coos Bay (Figure 41). The State of Oregon excercises ownership to the Upper Island. The Corps plans new disposal on the island no later than 1977; plans for use of the site after that are indefinite (Mr. A. Heinan, Personal Communication). The economic costs of implementing tne proposed habitat enhancement of the Upper Island site should be on the order of $3000 tc $7000.

116. Construction of all of the proposed alternatives for the five sites requires more detailed engineering than presented in this report. On-going studies by the WES on the stability and construction of dredged material disposal dikes should provide these details. Reference is also made to Garbe 1974 in which a new technique for dredged materials dewatering and reclamation is described.

Enhancement Schemes

Great Lakes Region - Grassy Island

117. Grassy Island in the Detroit District is proposed as a test site to determine the feasibility of enhancing and developing upland habitats, wetlands, and open-water

conditions. Target species will include waterfowl in the wetlands and open-water areas and cottontail and ring-necked pheasant in the upland habitats. Management schemes for these species are presented in Appendix C.

118. Approximately an eight-acre area for upland habitat is suggested. The optimum sediment type would be free-draining silty sand to sand. An eight-acre wetland habitat is also proposed in which water depths would be 0.2 to 0.5 m and desired sediment would be a silty clay to silt. An open-water area with water depth from 0.5 to 1.0 m is also proposed. Polluted sediments should be covered if tests reveal that this is necessary. Establishment of appropriate floral species such as cattail and rice cutgrass will be necessary, although cattails will not need introduction since they currently occupy small portions of the site.

119. To accomplish these goals, Grassy Island will be diked (Fig. 15). Upland area #1 will be filled with dredged material (presumably silty sand) to a completed level, followed by filling of upland area #2. While upland area #2 is being filled, #1 will be undergoing succession and will provide a vegetative colonizing source for area #2 upon final disposal.

120. Sediment-laden water bearing finer particles will pass into the wetlands and open water (area #3). The more elevated portions of this section will develop into wetland conditions. Deeper waters will prevail in the general vicinity

of the outlet spillway. Finer sediments will drop from suspension in an area between spillways A and B and the outlet spillway serving as substrate for wetland plant species. The area north of areas #1 and #2 will not be included in the test program.

North Atlantic Region - Pedricktown-Penns Grove

121. Experiments within the Philadelphia District at the Pedricktown-Penns Grove site (Figure 21) will involve replacement of common reed with upland vegetation which will succeed toward more mature stages. Initial experimentation will define the most satisfactory means of quickly arresting common reed stands.

122. Three test strips 762 m long by 45.6 m wide are proposed on this site. Herbicide application (H_1), controlled burning (B), trampling by vehicles (T), and harvesting by hand or vehicle (H_2) would be done in randomly selected plots within each strip. Three experimental areas of each of the above stresses and three control plots (C) would be included in each strip. The randomized experimental design of strips and plots is indicated on Figure 21. Test area #1 would have these stresses applied once a year, #2 twice a year, and #3 three times a year.

123. Professional support for herbicide application would be obtained. Dalapon, glyphosate, and Amatrol have been tested for their effectiveness against common reed. Dalapon

has produced good results (Mr. D. D. Riemer and D. Basslar, Personal Communication). Application of stresses will take place at times in which the effects would be maximized. Common reed reinvasion will be monitored on a tri-weekly basis during the growing season. When control is certain, the soil will be tested for agricultural potential and treated to obtain proper nutrient and chemical properties. In order to prevent soil erosion, maintain friability, and add nitrogen, planting of wheat, legumes, and grasses will occur. This will speed colonization by other vegetation.

124. The agricultural crops and grasses would not be maintained. Subsequent indigenous colonizers should be monitored in terms of species, value to upland wildlife, and rate and extent of colonization. If succession continues satisfactorily during the first two years, various indigenous trees would be transplanted. These trees should include those associated with young hardwood forests, such as aspens and ashes. Caution must be taken to plant trees which tolerate transplantation or artificial seeding well. The vitality of trees would be monitored in terms of leaf appearance. Soil tests should be run in areas where any trees fail to persist. Nutrient or mineral deficiencies should be satisfied through routine soil amendments.

<u>South Atlantic Region - No. 2 Savannah</u>

125. Enhancement goals at the No. 2 Savannah test area (Savannah District) include:

Suitable tern and skimmer nesting habitat

Freshwater marsh

Shorebirds feeding and nesting area

Upland habitat.

126. Figure 26 shows the proposed dikes and enhancement goals for each compartment. The coarsest particles from the dredged material will settle in area #4. The finer grained material will settle out in the freshwater marsh (area #2 and #3). The water which is relatively sediment free will pass out flood gates A and B. During this process flood gates D, G, and I will be shut.

127. The freshwater marsh areas will be handled in two ways. Area #2 will fill with rain water. Area #3 will fill with rain water, gate C will be opened, and this area flushed. Area #3 will then refill with rain water. Such treatment will allow evaluation of the effects of residual salt content in area #2.

128. The marsh compartments must be undisturbed by frequent disposal operations, but the tern colony area needs this disturbance to maintain a barren habitat. Overflow water and sediment could either go through gate G, and then through gate D if water is needed in the shorebird feeding area or be discharged through gate I if such water input is not needed.

129. The tern and skimmer nesting colony area should be about 40 acres in size with fine to coarse sand. High vertical

permeability coefficients are required to prevent ponding. Only minimal vegetation can be permitted. Sand mounds one to two m high with relatively level crests should be provided to maximize potential for nesting (Dr. L. B. Davenport, Personal Communication). Steeply sloped surface conditions (2 horizontal to 1 vertical) are poorly suited for egg stability in the nest. During the breeding season, predator control may be required.

130. A freshwater marsh about 25 acres in size divided into two equal parts will be developed. As mentioned earlier, one part will be flushed with fresh water and the other not. Standing water of no more than one ppt salinity and approximately 0.8 m in depth will be needed. Chemical analysis data (Table 2), however, show high chloride levels for parts of No. 2 Savannah. Monthly salinity checks of each confinement should be taken. On-site meteorological data should be taken including precipitation, evaporation rates, temperature, and humidity. These data will help identify the role rainwater will play in establishing the surface water characteristics. To maintain water levels, fine-grained sediments with low vertical permeability coefficients (10 cm/sec) as found at the east end of the secondary transect on No. 2 Savannah would be required. Once these conditions are met, cattails can be used as the colonizers.

131. A 40-acre feeding and nesting area for shorebirds, specifically the black-necked stilt and American avocet, is

proposed. The habitat structure will be a shallow pond of brackish water (10-20 ppt) with an average depth of 0.3 m. Sediments should consist of a sandy silt. Mounds 0.3 to 1.0 m above water level and 10 to 12 m in area should be placed at several locations about the compartment. These mounds act as nesting sites for the stilt and roosting areas for shorebirds (Dr. L. B. Davenport, Personal Communication). Dikes should be constructed to allow flooding by highest spring tides which will function to introduce prey species into the compartment. A management regime for predators similar to that used for the tern and skimmer colony should be implemented during the breeding season.

132. An upland habitat of approximately 20 acres (area #5) is proposed. The area will need a mixture or layering of silt and sand to retard drainage, yet not cause ponding. Dredged material test data (Table 2) show a need to neutralize the basic pH to 7 or 8. Nutrient and topographic modifications will need to be included in this experimental regime.

133. The effects of two parameters on colonization rate and composition will be tested in this habitat. The parameters are slope and nutrient levels. Half the area will be leveled and half left with the slope obtained from disposal. Each area will be divided into test sections for treatment at different levels of nutrient application. For purposes of statistical evaluation, at least three areas of each application or control should be randomized in the

experimental layout. Soil analyses and productivity harvests should be made to monitor the status of each area.

134. The intent of upland section studies is to evaluate the potential for accelerating succession on the many small disposal mounds which exist along this portion of the Savannah River and along the Atlantic Intra-coastal Waterway. As shown from the Oyster Bed Island soil analyses (Table 2) attempts to lower the pH to a point near neutrality, to increase the nitrogen levels, and to lower the chloride levels will likely be necessary in parts of the experimentation. The amounts of and chemicals to be applied would be determined after the disposal operation. As vegetation develops, estimates of net annual primary productivity and ground cover should be made. Soil characteristics in control areas should be determined in detail on an annual basis. Thus vegetation species composition can be evaluated in terms of the different experimental regimes and compared to similar existing communities on control sites. These can then be compared with existing disposal areas, such as Oyster Bed Island and other areas near No. 2 Savannah.

Gulf Coast Region - Station 41 of the MRGO

135. The enhancement goals for the MRGO site in the New Orleans District include:

osprey nesting and roosting stations

bobwhite game-release habitat

mourning dove feeding and nesting habitat

swamp rabbit habitat.

136. Osprey nesting and roosting stations would be constructed at locations at least 30 m apart within the site (J. C. Ogden, Personal Communication). These stations are platforms on a 5 to 6 m pole in an open space with a commanding view of the general area. The platform is circular (2 to 2.5 m diameter) and has 10 cm vertical dowlings surrounding the platform edge. Sticks and twigs should be placed in the platform to encourage nesting. Structures similar to this have proven highly successful in the Great Lakes area (S. Postupalsky, Personal Communication).

137. Compartment #1 will be filled to create a 40-acre bobwhite game release area (Figure 35). Soybeans would be planted after chemical tests are performed and nutrient deficiencies corrected. Shrubs and pines would be established in several portions of this agricultural habitat to provide fall and winter food and cover. The agricultural and shrub interspersion described for the bobwhite will also be suitable for the mourning dove feeding and nesting.

138. Section #2 of the test confinement will be filled with sediment-laden water allowed to enter through a control gate from the main portion of the disposal area. This area of fine-grained sediments will be managed for swamp rabbit (Appendix C). Grasses and sedges will be planted and rabbits stocked if necessary.

Pacific Coast Region - Upper Island of Coos Bay

139. In the Portland District, the Upper Coos Bay was selected for development of and acceleration of upland succession rates. Near the middle of the island, two five-acre ponds (confined) with an average depth of 0.5 to 1.0 m are proposed. The specific location of the ponds is not indicated in Figure 41 since many low lying locations are feasible. The remaining scheme and needs would resemble that of the freshwater marsh proposed on the No. 2 Savannah site. Colonizer sources would originate from nearby freshwater marsh habitats. A ten-acre plot for upland habitat development and successional acceleration would be constructed on the highest portion of the island. A scheme similar to that of the upland habitat at No. 2 Savannah would be used. Agricultural crops important to wildlife such as corn and millet should be planted after spring flooding periods.

140. Roosting habitat for bald eagles, osprey, purple martins, and great blue and green herons would be established. This can be accomplished by the placement snags and poles on the site. At present few lookout points are available in the area. Snags and poles will be used as artificial roosting sites. The osprey may also find them suitable for nesting.

PART V: COSTS AND BENEFITS OF ALTERNATIVES

Environmental and Economic Costs

141. The environmental costs incurred from disposal of dredged material and development of proposed alternatives are the loss of vegetation and wildlife habitat from unplanned sequences of disposal. Of the 15 sites observed during the field studies for this report, only Drum Island had planned disposal operations to mitigate loss of vegetation. Dredged material covers the herbaceous ground cover of a portion of any site during disposal operations, resulting in environmental costs. The depth and contaminant characteristics of dredged material dictate the recovery of perennial vegetation. Shrubs and trees are usually not disturbed by disposal operations, unless there are markedly different chemical characteristics in the dredged material or they are not tolerant of standing water.

142. The economic costs of proposed alternatives to disposal which are aimed at development or enhancement of habitat were presented in Part IV. These costs varied from about \$5,000 to \$27,000. The major expenses included equipment and labor to construct internal dikes and control flood gates. These costs would be incurred only once, but periodic dike maintenance and subsequent raising of the dike heights to accommodate settlement or additional material would increase costs. No estimate of such costs was made. Management of

developed habitats will require salaries for District biologists and support labor. A speculative figure for such expenses would be on the order of $25,000 per year for the five test sites.

Benefits of Proposed Alternatives

143. Enhancement of dredged material disposal sites to reestablish some natural resources is most desirable. The remainder of this section describes potential benefits derived from multiple use of dredged material. Comparisons are made between the enhanced value of studied disposal sites and present habitats.

Refuge Areas

144. Habitat for shorebirds and waterfowl is becoming increasingly scarce. Wetlands and tidelands are preferred habitats for many of these species. The Environmental Protection Agency and many states have formally described these habitats as valuable natural resources and as such they should be carefully protected and monitored. Similarly, upland game species require refuge areas where protection is afforded and food production can be augmented. Use of disposal areas for waterfowl management has been contemplated in South Carolina. The costs of management and loss of productivity through repeated disposal have inhibited action in this area (Mr. W. Brock Conrad, Jr., Personal Communication).

New Breeding and Feeding Grounds

145. Dredged material disposal areas are providing significant feeding and breeding habitat for threatened and rare species and for valuable game and non-game animals. Downing (1973) noted that less than 20 percent of least tern and black skimmer colonies from New Jersey to Mississippi were on natural beaches and dunes. Eighty percent were on man-made habitats, usually dredged material sites. Locally rare species such as the black-necked stilt and avocet in Georgia and South Carolina have benefited from dredged material disposal sites in terms of nesting and feeding (Dr. L. B. Davenport, Personal Communication). Gull-billed terns have successfully used such sites for nesting. The MRGO sites, No. 2 Savannah, and Drum Island were noted during our studies as feeding areas for raptors, particularly marsh hawks.

146. Non-game wildlife such as passerines, small and medium-sized mammals, raptors, and fish and other aquatic life can benefit from biologically productive habitats. For example, wooded acreage is declining in most areas of the country. With this habitat loss is a loss in numbers of many associated species, including thrushes, warblers, woodpeckers, and nuthatches.

Establishment of Mature Habitats

147. Mature habitats require considerable lengths of time to develop and "stabilize". Forests often take upwards

of 200 years to mature. The general trend today is toward the more immature habitats. One regional planning emphasis should be to reestablish mature environments. One way would be to allow disposal sites to mature unimpeded after the final disposal operation. Regional and site diversity would be enhanced by permitting this event. The Riverside site (Detroit District) is an excellent demonstration of how a disposal site can increase regional habitat diversity and augment a resource. High altitude color photography taken by NASA (scale 1:120,000) of the Toledo, Ohio area shows remarkably little wooded stands within a several hundred square mile area surrounding this site. Although the deciduous vegetation on the site is still immature, it already represents an almost unique habitat to the region. Mature habitats are more protective of their environments and are inherently more stable than immature systems. Tennessee Chute woods, for example, which are mature, are more persistent than the less mature habitats subjected to the same disposal regimes. Their persistence is gained from stronger structural features, and photosynthesis machinery above the disposal material.

Increased Habitat Diversity

148. The significance of diversity has been previously discussed. Other examples of regional diversity created by disposal of dredged material include Oyster Bed Island and

No. 2 Savannah. Each of these areas provides nesting habitat suitable for several tern species, skimmers, and black-necked stilts. Appropriate habitats for these species are rare from the middle coast of South Carolina south to St. Augustine, Florida.

149. An increase in diversity within a disposal site will accommodate an increased number of species, some of which will use only one habitat and others which may nest in one and feed in another, such as the mourning dove.

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Legend To Species Encountered Along Vegetation Transects

Common Name	Scientific Name	Symbol
Alder	*Alnus rugosa*	
Alligator weed	*Alternanthera philoxeroides*	—
Arrow-wood	*Vibirnum dentatum*	
Ash	*Fraxinus* sp.	
Aspen	*Populus tremuloides*	
Aster	*Aster* sp.	
Avens	*Geum* sp.	
Beach grass	*Ammophila arenaria*	
Beard grass	*Andropogon glomeratus*	
Birdsfoot trefoil	*Lotus corniculatus*	
Blackberry	*Rubus* sp.	
Black rush	*Juncus roemarianus*	
Box elder	*Acer negundo*	
Buffalo burr	*Solanum rostratum*	
Bulrush	*Scirpus* sp.	
Butterfly-bush	*Buddleja davidi*	
Cactus	*Opuntia* sp.	
Canada fleabane	*Conyza canadensis*	—
Chaparral broom	*Baccharis piluleris*	
Clover	*Trifolium* sp.	

-Indicates that a species was not dominant at any station of the vegetation transect, and as such they were not symbolized in the illustration.

Common Name	Scientific Name	Symbol
Coast alkali grass	*Puccinellia pratense*	
Cocklebur	*Xanthium* sp.	—
Coco	*Scirpus robustus*	
Common elder	*Sambucus canadensis*	
Common groundsel	*Senecio vulgaris*	—
Common horsetail	*Equisetum arvense*	—
Cottonwood	*Populus deltoides*	
Crabgrass	*Digitaria* sp.	
Curly dock	*Rumex crispus*	
Dodder	*Cuscuta indecora*	—
Dogfennel	*Eupatorium capillifolium*	
Early hair grass	*Aira praecox*	
Eastern baccharis	*Baccharis halimifolia*	
English plantain	*Plantago lanceolata*	
Glasswort	*Salicornia bigelovii*	
Glasswort	*S. virginica*	
Golden aster	*Chrysopsis* sp.	
Goldenrod	*Solidago* sp.	
Gumweed	*Grindelia integrifolia*	
Honeysuckle	*Lonicera* sp.	
Italian rye grass	*Lolium multiflorum*	
Jerusalem-cherry	*Solanum pseudo-capsicum*	—
John foxtail	*Setaria magna*	—

Common Name	Scientific Name	Symbol
Legume	Family: *Leguminosae*	
Loblolly pine	*Pinus taeda*	
Maritime peavine	*Lathyrus japonicus*	
Marsh aster	*Aster tenuifolius*	—
Marsh elder	*Iva frutescens*	
Olney's threesquare	*Scirpus olneyi*	—
Panic grass	*Panicum* sp.	
Pearly-everlasting	*Anaphalis margaritacea*	—
Pig weed	*Amaranthus* sp.	
Rabbitfoot polypogon	*Polypogon monspeliensis*	—
Ragwort	*Senecio glabellus*	—
Red clover	*Trifolium pratense*	
Red maple	*Acer rubrum*	
Red mulberry	*Morus rubra*	
Reed	*Phragmites communis*	
Reed canary grass	*Phalaris arundinacea*	
Rush	*Juncus* sp.	
Salt-marsh aster	*Aster exilis*	—
Saltmarsh bulrush	*Lythrum lineare*	—
Saltmeadow cord grass	*Spartina patens*	—
Saltwort	*Batis maritima*	
Scot's broom	*Cystisus scoparius*	
Sea ox-eye	*Borrichia frutescens*	—

Legend to Species (continued)

Common Name	Scientific Name	Symbol
Sea rocket	*Cakile edentula*	
Seashore lupine	*Lupinus littoralis*	
Seashore salt grass	*Distichlis spicata*	
Seaside goldenrod	*Solidago mexicana*	
Sedge	*Carex* sp.	
Smart weed	*Polygonum* sp.	
Smooth cord grass	*Spartina alterniflora*	
Solanum	*Solanum americanum*	—
Solanum	*S.* sp.	
Sorrel	*Rumex acetosella*	—
Spiny-leaved sow thistle	*Sonchus asper*	
Spotted cat's-ear	*Hypochoeris radicata*	
St. Augustine grass	*Stenotaphrum secundatum*	—
Sugarberry	*Celtis laevigata*	
Sumac	*Rhus* sp.	—
Sweet gum	*Liquidambar styraciflua*	
Sweet vernal grass	*Anthoxanthum odoratum*	
Sycamore	*Platanus occidentalis*	
Tearthumb	*Polygonum sagittatum*	
Thistle	*Cirsium* sp.	—
Tropical cattail	*Typha domingensis*	—
Umbrella sedge	*Cyperus strigosus*	—
Unknown composite		
Unknown grass		

Legend to Species (concluded)

Common Name	Scientific Name	Symbol
Unknown #1		—
Unknown #2		
Velvet grass	*Holcus lanatus*	III
Water-hemlock	*Cicuta curtissii*	—
Watson's willow herb	*Epilobium watsonii*	—
White clover	*Trifolium repens*	
White sweet clover	*Melilotus alba*	
Wild carrot	*Daucus carota*	—
Willow	*Salix* sp.	
Yarrow	*Achillea millefolium*	
Yellow sandverbena	*Abronia latifolia*	
Yucca	*Yucca* sp.	

BRAUN-BLANQUET SCALE OF COVER AND ABUNDANCE
(Phillips 1959, p.34)

+ Sparsely or very sparsely present, cover very small.

1. Plentiful but of small cover value.

2. Very numerous, or covering at least 1/20 of the area,

3. Any number of individuals covering 1/4 to 1/2 the area.

4. Any number of individuals covering 1/2 to 3/4 the area.

5. Covering more than 3/4 of the area.

Appendix A

Acknowledgements

1. Agencies and/or persons other than CE personnel who were contacted during the conduct of the contract study are listed below.

Mr. D. Bassler	Mountainside, N. J.	Western Soil Mgmt.
Mr. Ted Beckett	Charleston, S. C.	Magnolia Gardens
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Mr. Jack Calhoune	State of Illinois	Div. Fish & Game
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Mr. W. Brock Conrad, Jr.	Columbia, S. C.	S. C. Wildlife Resources Dept., Game & Fish Dept.
Mr. Stewart Critcher	Raleigh, N. C.	N. C. Wildlife Reserve Comm., Div. of Game.
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EPA	Chicago	Regional Office
Mr. Richard Hager	Washington, D. C.	Office of Legislation, Intergovt. Rel. Div.
Mr. Charles Howard	Philadelphia	EPA Regional Office
Mr. Paul Jones	Dallas	EPA Regional Office

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Mr. D. N. Riemer	New Brunswick, N.J.	Assoc. Research Prof., Aquatic Weed Science, Rutgers University

2. CE personnel consulted during initial site visits were as follows:

Mr. Don Billmeyer	Detroit District	Dredging Operations
Mr. William Clarkson	Savannah District	Asst. Chief of Operations
Dr. M. A. Cooper	Detroit District	Supervisor, Environmental Biology
Mr. Ron Creh and Mr. Harold Griffith	Philadelphia District	Dredging Operations
Mr. Adam Heinan	Portland District	Operations Division
Mr. Tom Lawless	Norfolk District	Chief of Operations
Mr. Edward B. McChee	Galveston District	Asst. Chief of Operations
Mr. C. J. Nettles, Jr.	New Orleans District	Asst. Chief of Operations

Mr. Forest Pruitt	Mobile District	Asst. Chief of Operations
Mr. A. B. Richardson	Memphis District	Operations Division
Mr. Lawrence Snider	Charleston District	Operations Division
Mr. John Sustar	San Francisco District	Chief of Dredged Material Disposal
Mr. Gerald Wilkerson	Memphis District	Operations Division

Appendix B

Field Checklist Form

PROJECT: U. S. Army Waterways Experiment Station
Review and Examination of Disposal Area Filling Techniques and Rates to Identify Nonconflicting Wildlife Enhancement Alternatives

CONTRACT: DACW39-74-C-0033

JOB NO: 9486- ___-___

TIME AND DATES OF INSPECTION:

Field Personnel: (Name) ____________________

Contact Officer: (Name) ____________________

Site Name: ____________________

I. PHYSICAL CHARACTERISTICS OF SITE: (Name) ____________________

____

Location (state, district, quadrangle, coordinates, miles and directions of nearest town)

____

____

Surrounding Area (i. e., 1 to 2 miles)

1. Topography (rolling, flat, steep) ____________________

____

2. Elevation relief (MSL) (7.5 min Topography Sheet) ___

____

3. Sources of fill (nearby gravel and sand pits, or other)

____

4. Surface water drainage and quality (i.e., EPA classification)

____

On site (Take color photographs of site and draw schematic showing roads, access and discharge points.)

1. Site description (i.e., maximum, minimum elevation):

____

2. Existing man-made structures (i.e., dikes, borrow ditches)

____

3. History of stability of structures and land subsidence of areas (i.e., failed dikes, wave erosion, flooding history): _______________

____

4. Existing surface water drainage (direction of flow, estimate of quantity - cfs - in ditches, streams irrigation systems, tidal fluctuations):

____

____

5. Access to site (type of roads and size; water, rail or barge access):

____

____

6. Estimated total depth (feet):

____

7. How long has area been used: (years, months)

____

8. Dimensions of site (acreage): _______________

9. Estimated economic value of land ($/acre based on surrounding land cost) and ownership:

____

____

10. Qualitative assessment of water in areas of dredging (source, i.e., paper pulp discharge area, sewage disposal area):

____

____

11. Depth of frost(average): _______________

II. DREDGING OPERATIONS (maintenance dredging)

1. Type of dredge (i.e., suction, cutterhead, dustpan, clamshell):

   ____

2. Capacity of dredge (cuyd or cfs): ______________

3. Frequency of operation (annual, biannual, other):

   ____

4. Duration of operation per site (i.e., 6-day week/24 day and average number of working days per time of year):

   ____

5. Total quantities of dredged material placed per operation (cuyd or cfs):

   ____

6. Number of discharge locations to site: ____________

7. Maximum length of discharge lines (feet): __________

8. Legal and economic constraints (i.e., local or federal legislation, wetlands acts, and acquisitions; construction on existing disposal areas):

   ____

   ____

   ____

   ____

   ____

   ____

   ____

III. DREDGED MATERIAL CHARACTERISTICS

Disposal Site

1. On-site Profile:

   a. Soil classification/particle size (i.e., qualitative description): ______________________

   ____

   b. Estimate of permeability (qualitative estimate, i.e., high, low, impermeable and basis for estimate):

   ____

   c. Compressibility (i.e., high, low): ______________

   d. Estimate of in-situ density (pcf): ______________

   e. Estimate of density during transportation to site (pcf):

   ____

   f. Estimate of density after deposition (pcf):

   ____

2. Surface Drainage of Area Between Deposition Periods (yes or no and explain):

   ____

   ____

   ____

3. Chemical Characteristics:

   a. Oxidized (smell): ______________________

   b. Contaminates (soluble, i.e., inquire with local Water Quality Control Board):

   ____

   c. Organic content (i.e., wood fibers): ______________

   ____

4. Segregation along biological transect within material <u>after</u> discharge (i.e., silt pockets):

____

____

5. Comparison of past to present dredged material characteristics (i.e., past more organic than present, particle size different):

____

____

____

____

____

____

____

VEGETATION TRANSECT DATA SHEET

Observer ______________________ Date ______________

Site Name ____

Origin point of primary transect ________________________

Compass heading of primary transect _____________________

Compass heading of secondary transect ___________________

Location of secondary transect along primary transect ______________________________________

General appearance of site and surrounding environs[1]

____

____

____

____

____

____

____

____

____

[1] Comment on soil appearance, elevation of dike and disposal area, location of any standing water, general characterization of area, vegetation, i.e., scrubby layer or trees etc., faunal signs such as scat, tracks, or direct observation. Also indicate proximity of various vegetative habitats (colonization sources to the site such as woods, marshlands, etc.); approximate heights of vegetation.

TRANSECT STATION DATA SHEET

Observer ____________________ Site Name ____________________ Date ______________

Transect No. ________________________ Station No. ____________________________

Distance interval between this and last station ___________________ ________

Elevation change between this and last station ____________________________

General comments such as birds seen or heard or mammal tracks observed along this part of transect, or tidal influences etc.

____

____

____

Herb layer (plants including woody vegetation - 1" depth)

Species	Scale of Cover Characteristics	Photo Taken - Sample # if Specimen Taken

Tree layer (plants - 1" depth)

____

____

____

NOTE: Whenever a station occurs at a recognizable spot on the photography this must be included and underscored on the appropriate sheet.

APPENDIX C

TARGET SPECIES

THEIR REQUIREMENTS AND MANAGEMENT TECHNIQUES

Mourning Dove (*Zenaida macroura*)

A. Food Preferences

1. Regional preference (highest preference at top of list; Martin et al. 1951):

North Atlantic	South Atlantic	Great Lakes
Bristlegrass	Corn	Pigweed
Corn	Bristlegrass	Corn
Wheat	Crowfoot-grass	Doveweed
Buckwheat	Cow-pea	Bristlegrass
Ragweed	Crabgrass	Spurge
Pokeweed	Ragweed	Wheat
Knotweed	Oats	Knotweed
Crabgrass	Pine	Sunflower
	Doveweed	

2. Seeds and other plant materials constitute practically 100% of their diet throughout the year (Martin et al. 1951).

B. Habitat Requirements

The Mourning Dove lives in many kinds of habitat from farmlands, hedgerows, woodlands, orchards and arid areas. Woody plants are essential as individual plants rather than extensive cover (Edminster 1954). Conifers and medium shrub provide good nesting habitat (Caldwell 1964).

C. Management Techniques

Due to the migratory nature of this species, management schemes can provide only nesting and feeding habitat. In creating the habitat we recommend the area be above the water table and moderate to well-drained. Relatively dry soil also conditioned for agriculture is ideal for producing the desired plant growth. Croplands for feeding should be a substantial amount of the habitat with open fields, hedgerows, woodlots, and wood margins as adjacent nesting areas.

a. References are given in Literature Cited.

Stocking is not necessary since the Mourning Dove is a migratory species. When the desired habitat is met the species will inhabit the area. There is probably no need to locally regulate their numbers due to the wide-ranging nature of this species.

The management of the Mourning Dove is primarily the control of the hunting harvest. Strict attention should be given to control the harvest in general areas (Edminster 1954).

Ruffed Grouse (Bonasa umbellus)

A. Food Preferences

1. Adults - almost entirely vegetable matter with small amounts of insects in the summer.

2. Young - large quantities of insect larvae, beetles, flies, spiders and ants (50 - 75 percent in first month, 10 - 15 percent in 2nd) (Edminster 1954).

3. Regional Preferences (Highest preference at top of list; Martin et al. 1951, and Korschagen 1966):

North Atlantic Region		Great Lakes Region	
Northeast Winter	Virginia Winter	Ohio-Missouri Winter	Wisconsin
Aspen	Oak	Greenbrier	Aspen
Clover	Grape	Aspen	Hazelnut
Hazelnut	Greenbrier	Dogwood	Clover
Birch	Wintergreen	Grape	Cherry
Greenbrier	Mt. laurel	Sumac	Blackberry
Sumac	Sheepsorrel	Beech	Birch
Grape	Pussytoes	Witch-hazel	Dogwood
Apple	Blueberry	Oak	
Hawthorn	Hazelnut	Bittersweet	

B. Habitat Requirements

Productive habitat for grouse would contain an interspersion of the following cover types (Edminster 1954):

Cover Type	Season of Use	Functions Served
Open land - farm fields; roads; mountain meadows; bare land; marshes.	Summer; some in spring and fall	Enhances value of adjacent cover; dusting and sunning.
Brushy areas - overgrown fields; slashings, alder runs; aspen-pin cherry burns	Summer and fall; some in spring	Brood cover; fall feeding; summer feeding and dusting, some spring and winter feeding

B. Habitat Requirements (continued)

Cover Type	Season of Use	Functions Served
Hardwood woodlands - Appalachian hardwoods; northern hardwoods; old aspen-pin cherry burns; western hardwoods	Spring, summer, and fall	Nesting; fall and winter feeding
Mixed Woodlands - variety according to combination of hardwood and conifer species	All year	General feeding and shelter cover, except for summer
Coniferous woodlands - variety according to predominant species of conifers	Winter; some in spring and fall	Winter shelter; escape cover and storm shelter

C. Population Densities

Somewhat cyclic, maximum in spring of about 1 bird/8 acres to 1 bird/22 acres in south-central New York (Edminster 1954).

D. Management Techniques

Creation of an upland habitat (above the water table) of primarily moist sand loam soil from dredge disposal site can be accomplished with plantings or through natural succession. Plantings could include (Edminster 1954):

1. Developing shrub borders by planting multiflora rose, silky dogwood, crabapple, autumn olive, bayberry, tartarian honeysuckle, etc. This could be achieved by spacing larger species approximately 4 ft. apart and smaller ones about 2 to 3 feet apart.
2. Establishing small areas of conifers such as white, red and scotch pine; Norway, red and white spruce.

Additional habitat management techniques include:

1. Exclusion of grazing from wooded habitats
2. Selective cutting for sustained yield or small block or strip clear-cuts in a rotation, with the clear-cuts being particularly important in providing first clearings and later a shrub stage. Stands of aspen can be maintained by maintaining a 10 or 20 year cutting cycle (Berner and Gysel 1969).
3. Border cutting of woodlands (25-30 ft.) adjoining cropland (Edminster 1954).

The area should be allowed to grow to desired state before the grouse is stocked or imported from nearby habitats. Population control can be achieved through limited hunting; during open seasons of good abundance. Often, however, rather liberal hunting is allowable.

Control of succession in the shrub areas may be achieved by hand applying herbicides in specific areas or mechanical removal. The narrow strips of grasslands should be periodically mowed or burned during the late summer on a rotating schedule to control succession (Edminster 1954).

Woodcock (*Philohela minor*)

A. Food Preferences

Martin et al. 1951

1. Animal matter - 90 percent; 2/3 of that being earthworms, the rest being beetles, caterpillars and grasshoppers.
2. Plant matter - 10 percent; bristlegrass, blackberry, panicgrass, sedges, etc.

B. Habitat Requirements

1. Spring
   a. Open-grassy for courtship and breeding, with openings of 1/4 acre in size being adequate (Liscinsky no date).
   b. Brushy cover or second-growth hardwoods for nesting, roosting and feeding with alder and aspen being preferred species (Edminster 1954).
2. Summer
   a. Cover areas about the same as in spring
   b. When area gets too dry - may move to wetter habitats (along streams, spring seeps, etc.) (Edminster 1954).
3. Fall

   During migration cover for food and resting needed, alder thickets along streams preferred (Edminster 1954).
4. Winter

   Streams, swamps and marshes of southern states bordered with swamp hardwoods (gums, wet ground oaks and maples), pine knolls, rice fields, etc. (Edminster 1954).

C. Population Densities

Edminster 1954

1. Spring

    a. Pennsylvania - 9.5/100 a.

    b. Maryland - 3/100 a.

    c. Wisconsin - 3-3.6/100 a.

    d. Massachusetts - 4/100 a.

2. Fall

    Pennsylvania 20/40/100 a.

3. Winter

    South 1/2 to 2 birds/acre in wintering areas

D. Management Techniques

In creating the habitat, we recommend the area should be above the water table and have a lowland partially drained and an upland well drained areas. The soils can vary somewhat from clay to sandy loams. Sandy soils should be avoided since they are the least favorable for production of earthworms, the Woodcock's major food. Highly acidic soils are also detrimental for earthworm production (Liscinsky no date).

Woodcock habitats include early successional stages of plant communities. A suitable habitat can be propagated by initial planting of some portions of the site. Planting a group of scrubs will serve as a nucleus from which a thicket will form. It is not necessary to plant extensive areas or to follow a set pattern of arrangement. Alder is the most beneficial and easily propagated of the shrubs preferred by Woodcock (Liscinsky no date). Alder covers can be established in the lowland areas by planting seedling stock and by direct sowing of seeds. Upland areas should be planted with aspen. Aspen is relatively intolerant to shade and must have practically full sunlight to reproduce (Liscinsky no date). If a hardwood forest is located on the site a strip between the hardwoods and lowland shrubs should be clearcut to rejuvenate the habitat into a second growth which is preferred by Woodcock.

Of primary concern is to maintain suitable habitat that will provide small clearings for courtship and breeding, and adjacent areas of cover. This can be achieved by (Liscinsky no date):

1. Planting - in areas without suitable cover such as bottomlands near streams and areas adjacent to ponds and marshes, shrubs such as alder, gray and silky dogwood, hawthorn, etc. could be planted to make the site more attractive to Woodcock.
2. Cutting - using small clearcuts, release cuttings and thinnings to rejuvenate and maintain the habitat.
3. Spraying - use of herbicides such as a solution of 2, 4, 5-T and fuel oil on freshly cut stumps to retard sprouting.
4. Grazing - moderate use of 30 grazing days/acre may improve habitat.

Since the Woodcock is a migratory bird, there is no feasible way to introduce or increase population levels by methods such as stocking. The presence of suitable Woodcock habitat will be the main factor responsible for initiating or increasing the use of a specific area. However, due to its behavior and restricted habitat requirements, the Woodcock can be subjected to overharvesting (Liscinsky no date).

Bobwhite (*Colinus virginianus*)

A. Food Preferences

1. Adults are essentially seed eaters, while young require an almost exclusive diet of beetles, grasshoppers, crickets, caterpillars, etc. (Martin et al. 1951).

2. Regional Preferences (Highest preference at top of list; Martin et al. 1951):

North Atlantic	South Atlantic	Great Lakes
Ragweed	Lespedeza	Ragweed
Corn	Beggarweed	Corn
Smartweed	Oak	Bristlegrass
Bristlegrass	Partridge-pea	Sunflower
Wheat	Cow-pea	Wheat
Grape	Ragweed	Sorghum
Blackberry	Pine	Knotweed
Ash	Milk-pea	Panicgrass
Sumac	Soybean	Poison Ivy

B. Habitat Requirements

The carrying capacity of Bobwhite will be higher with greater interspersion of the following cover types:

(See Table C1)

C. Population Densities (Fall)

1. 1 bird / 3 acres - optimum in southeast (Edminster 1954)

2. Up to 1 bird / acre - Illinois (Ellis et al. 1969)

D. Management Techniques

The Bobwhite is a species whose activity is closely associated with edges - those lines, lands, or spots where two or more distinctive kinds of cover come together (Edminster 1954). Wise land-use of agricultural areas can do much to enhance the carrying capacity for Bobwhite. The following chart demonstrates the variety and best area size of the different

TABLE C1

COVER TYPES USED BY BOBWHITE (Edminster 1954)

Cover Types (and Variety)	Season of Use	Functions Served
Grassland Hay: alfalfa; clover; lespedeza; special grasses; grass and legume. Pasture: grass-legume; mixed grasses Roadsides and other odd areas Range: tall grass prairie; short grass prairie	Spring and summer mainly	Nesting, roosting in good weather; some feeding
Crop Fields, etc. Corn and small grains Cotton, tobacco, vegetables, etc. Weed fields and fallow Stabilized dunes	Summer and fall mostly; some in spring and winter.	Feeding; also for loafing, dusting; some for roosting
Brushy Areas, etc. Vine tangles Thickets of shrubs, briars, or rank tall herbs Hedges Scattered shrubs, as sagebrush and mesquite	Fall and winter; some in spring less in summer	Escape cover; fall and wint[illegible] feeding; roosting; loafing
Woodland Northern oaks and conifers (oaks, tulip-tree, beech, white pine) Southern pines (longleaf, slash, lob-lolly) Oaks, oak-hickory, post oak Southern oak-pines Southwestern bottomland hardwoods	Fall and winter; some in spring	Roosting; escape cover; win[illegible] and fall feeding

TABLE C2

LAND-USE PATTERN FOR GOOD BOBWHITE RANGE (Edminster 1954)

Cover Type	Proportion of Total Cover	Best Unit Size	Comment
Grassland	30 - 40%	5 - 20 acres	Good grass-legume mixtures; with Korean lespedeza whe[illegible] adaptable; full use of opportunities for protected gr[illegible] in sod roadsides, field boundaries, diversion terrac[illegible] waterways.
Crop Fields	60 - 40%	1 - 5 acres	On best soils, arranged in narrow contour field; corn and small grains grown as much as possible, and their culture completed early to get weedy aftermath.
Brushy Cover	5 - 20%	1/4 - 1 acre	Bicolor lespedeza woods borders, multiflora rose livin[illegible] fence hedges wherever suitable; honeysuckle, grape, greenbriar, plum, briar, scrub oak thickets on suitab[illegible] odd areas; no fire; no grazing.
Woodland	5 - 40%	5 - 20 acres	In small units except for old longleaf pine stands handled with prescribed burning; no grazing; abundanc[illegible] of good mast species like oaks, pines, sweetgum, and fruiting trees.

cover types.

(See Table C2)

In creating the habitat we recommend; 1) the habitat should be above the water table and moderate to well drained; 2) relatively dry loam soil would be best suited for development of grasslands, crop fields, and scrub areas.

Forest areas should be controlled by rotating cutting of small blocks at approximately 5 year intervals; this practice should be consistent with recommendations for the improvement and harvest of wood products. Other alternatives are strip-cutting and spot-lumbering of small groups of mature trees as they reach harvestable size. Resprouting of cut trees should be controlled with herbicides (Edminster 1954). Croplands should receive fertilizer and also be rotated to insure the amount as well as the quality of the food. Cutting grain crops high to leave as much stubble as possible will keep organic matter on the field surface (Edminster 1954). Management studies in Illinois have demonstrated that a program of prescribed burning to induce growth of shade-intolerant herbaceous plants and share cropping (leaving 25 percent of the crops for wildlife) have greatly increased the quail population. (Ellis et al. 1969). Cutting of hay and grasslands should be done as late as possible to prevent destruction of nests in these fields during early summer. Brushy areas and hedgerows should be controlled by applying herbicides by hand in selective areas.

To establish bobwhite on new areas, it would be best to release wild birds captured on nearby areas, releasing 15 to 20 birds together in high quality cover. (Edminster 1954). Stocking of game farm quail has proven to be unsuccessful in most cases with (Edminster 1954):

a. Stocking failing to increase existing populations

b. Few stocked birds surviving to the fall hunting season from late summer stocking

c. Birds released in the spring rarely breeding that year or surviving to the fall

d. Native quail populations doing better without additional stocked birds

Populations may be controlled by hunting or trapping. Hunting of quail in northeastern states is much less popular than in southeastern United States. In the northeast region quail populations can fluctuate due to additional stresses of the environment and a kill of 20 percent to 30 percent of the quail in years of scarcity might retard recovery (Edminster 1954). Before hunting is open the density of quail should be at least 15/100 acres (Edminster 1954).

Turkey (*Meleagris gallopavo*)

A. Food Preference

1. Adults (Edminster 1954)

Fall & Winter - 60% of diet - mast (oaks, beech, pine)

15 - 20% fruit (dogwood and wild grape)

Spring & Summer - 20% mast (oaks)

15% fruit (huckleberry, blueberry)

30% green seeds (grasses)

Grasshoppers

2. Young - consume more insects, succulent greens & fruits (Edminster 1954)

3. Regional food preference

North Atlantic	South Atlantic (Virginia-Georgia)	Coastal Woodland
Oak	Oak	Oak
Beech	Pine	Dogwood
Grasses	Beech	Greenbrier
Dogwood	Ash	Grasses
Wild grape	Dogwood	Beech
Huckleberry	Wild grape	Gums
Blueberry	Greenbrier	Pines
Blackgum	Blueberry	Hickory
Cherries	Huckleberry	Grape
Fern	Black gum	Huckleberry
Club mosses		Blueberry

B. Habitat Requirements

Productive habitat would contain combination of listed cover types, in minimum area of 10,000-20,000 acres, particularly having small openings interspersed at intervals of 1 mile or less (Edminster 1954).

COVER TYPE	SEASON OF USE	FUNCTION SERVED
Hardwood Forest Northern & Bottom land hardwoods, Appalachian-Ozark hardwoods, Rocky Mt. hardwoods. Shrubs of understory used.	Spring & Fall, less in winter and summer	Nesting, feeding, roosting, brood-raising.
Mixed Forest - Northern Conifers and hardwoods, Hard Pines & Appalachian hardwoods, Bottomland Pines and Rocky Mt. Conifers mixed with hardwoods.	All year - but least in summer good food and shelter	Protective shelter roosting, feeding nesting, brood-raising.
Coniferous Forest Northern Conifers, Hard Pines, Bottomland Pines and Rocky Mt. Conifers. Mature stands best.	Most used in winter, least in summer. Used all year in Rockies	Protective shelter, roosting, and feeding.
Forest Openings - Farm crop fields, Grasslands and Brushland.	Mostly in summer, least in winter	Feeding, brood-raising, dusting, sunning, nesting, courting.

C. Population Densities

Somewhat cyclic, maximum in fall-winter, over existing range, average density 1 bird/500 acres. On best portions of habitat, 2-8 birds/sq. mile (Edminster 1954).

D. Management Techniques

Dredged material disposal sites can be used to complement existing habitats required for Turkey management. To establish the required habitat, the area should be above the water table, but must have open water available in streams, spring heads or wooded swamps. Moist sandy loam is the best soil for the required vegetation. Plantings, establishing a range consisting of 50-70% oak hardwood, 15-30% coniferous forest and

15-20% grassland in alternate small units, or natural succession can be used to create appropriate habitat from the spoil site.

Habitat management techniques include (Edminster 1954):

1. Provision of open areas by group-selection cutting; leaving slashings of half acre or more, rotate so low-grade wood products obtained on recutting - 25 yrs. minimum. Spacing 1/10 mile apart. Patch-burning to slash suggested to induce germination of blueberry and huckleberry in areas between grasslands.
2. Controlled grazing, limited to area and by numbers to the condition that the range can support.
3. Harvesting of forest trees on sustained-yield schedule. Should be long-term, small unit-per-year rotation of cuttings; providing for interspersion of age classes with sufficient mature stands of trees.

Once the desired habitat is achieved, the area should be stocked to an appropriate population size. Flocks of 20 birds are suggested to achieve successful breeding. Annual censusing should be made by remarking boundaries or controlled hunting and trapping (Edminster 1954).

Ring-necked Pheasant (*Phasianus colchicus*)

A. Food Preferences

Adults are essentially seed eaters, while the young require an almost exclusive diet of insects during their first few weeks (Edminster 1954).

Regional preferences (highest preference at top of list) (Martin et al. 1951):

North Atlantic (exc. NY.)	Great Lakes	North Pacific
Corn	Corn	Barley
Ragweed	Blackberry	Wheat
Skunkcabbage	Apple	Oats
Grape	Grape	Corn
Oats	Wheat	Ragweed
Oak	Sumac	Bristlegrass
Elderberry	Oats	Russian thistle
Buckwheat	Strawberry	Dandelion
Cherry	Barley	Knotweed
Wheat	Beans	Sunflower

B. Habitat Requirements

Three types of cover are required: cropland, grassland, and woody or rank-growing herbaceous vegetation (Edminster 1954). Croplands are necessary for feeding grounds, while grasslands and thickets are used as nesting areas. Sown small-grain fields and corn fields are intermittently preferred for nesting or roosting (Hansen and Progulske 1973).

C. Population Densities

Spring (Edminster 1954)

1. 1 bird/ 3 to 4 acres (South Dakota)

2. 1 bird/ 8 to 10 acres (Southeastern Pennsylvania)

3. 1 bird/ 15 to 20 acres (Connecticut River Valley of Massachusetts)

D. Management Techniques

The habitat should be above the water table and moderately to well drained. The soil best suited for creating the habitat would be sandy loam especially for croplands. Areas where erosion is a problem should be planted with grasses and shrubs.

Planting of food patches in (corn) long and narrow strips adjacent to good shelter - a swale, woods or brush patch will increase the density of pheasants. These patches should be left unharvested. Control of habitat succession can be achieved by mowing the grasslands in late summer and by hand applying herbicides in selected areas. Croplands should be rotated to produce maximum productivity.

When habitats are in the desired state, stocking of birds may take place. Research has shown that stocking to increase the breeding population should take place in late March (game-farm birds) (Edminster 1954). Live trapping of wild birds from overpopulated areas is better for stocking than are game-farm birds, and frequently cost less to trap than to raise or purchase. Trapping should take place in early winter (Edminster 1954).

Areas of refuge from hunting should be established in areas of high density gunning. Pheasants respond well to the protection offered by refuges and this insures that all the birds in the area will not be killed during the hunting season (Edminster 1954).

Whitetail Deer (*Odocoileus virginianus*)

A. Food Preferences

Preferred foods have been demonstrated to vary greatly for different geographical areas due to the great variation in vegetation found growing in the various areas and for different seasons (Edminster 1954).

North Atlantic	South Atlantic	Great Lakes	Great Lakes
New York Winter	Alabama Winter	Wisconsin Winter	Ohio Year round
Maple	Oak	Dogwood	Wild crab apple
Witch-hazel	Greenbrier	Wintergreen	Corn
Sumac	Pine	Yew	Sumac
Aspen	Sumac	White cedar	Jap. honeysuckle
Birch	Dogwood	Hemlock	Grasses
Dogwood	Jasmine	Sumac	Greenbrier
Viburnum	Panicgrass	Red maple	Clover
Oak			Soybean

B. Habitat Requirements

- low mixed woodlands, forest edges, second growth hardwoods (Collins 1959).

C. Population Densities

1. Carrying Capacities

   High: 1 deer/10 acres - Mississippi and parts of New York

   Low: 1 deer/80 acres - Florida (Taylor 1956).

2. North Carolina - vary from 1 deer/10 acres to 1 deer/50 acres depending on habitat (Anthony pers. Communication).

D. Management Techniques

Creation of the habitats must be in an upland situation, thus requiring appropriate drainage of spoil areas and procedures to increase elevation if necessary. Desired wooded and shrub vegetation (maple, aspen, sumac, dog-wood, and oak) exhibit best development on moist, sandy loam soil but will persist on drier, rocky soils. This vegetation is best attained through natural succession to a wooded state. When the woods are sufficiently developed, deer can be stocked in the area if not available from a natural source. Deer could also use the shrub successional stage prior to woods development if other woods are situated nearby. Woods are necessary as deer demonstrate shelter seeking activity in response to severe weather (Ozoga & Gysel 1972).

In general a prime factor limiting deer density in northern states is the carrying capacity during the winter which is mainly correlated to amount of available browse. Several sivicultural practices can be used to improve browse production such as:

1. Clear cuttings - should be less than 50 acres in size (Nixon et al. 1970).
2. Partial cuttings and thinnings (Taylor 1956).
3. Release cuttings to release desirable plants from overtopping vegetation (Taylor 1956).
4. Prescribed burning to induce browse production and stimulate growth of herbaceous plants (Dills 1970).

Wild trapped deer can be successfully used to establish populations of whitetail in unpopulated areas. Hunting should be used as a management tool in areas where populations threaten to outgrow the carrying capacity. In other instances hunting may have to be restricted or not allowed to help deer herds build up to suitable levels.

Other Management Practices include:

1. Michigan
    a. Northern part of state - maintain a density of 30 deer/sq. mile.

b. Southern part of state - maintain a deer density at a low enough level that damage to agricultural crops is kept to a minimum. This density is usually less than 30 deer/sq. mile (Byelich pers. communication).

2. Louisiana - manage for maximum population density on a sustained yield basis without destruction of habit. A successful population has been established on one area where dredged sand has been deposited, with willow (<u>Salix</u> spp.) being the main woody species utilized by deer (Kidd pers. communication).

3. Virginia - Density in eastern part of state kept at levels to minimize crop damage. Management is achieved by restricting or liberalizing doe hunting, with successful reduction of the following year's population when the doe harvest comprises 35 percent or more of the total deer harvest (Cross pers. communication).

4. In areas of intensive agricultural practices such as the midwest, waste grains should be left in field through the winter, with plowing being restricted to the following spring (Nixon et al. 1970).

Eastern Cottontail (*Sylvilagus floridanus*)

A. Food Preferences

Regional preferences (highest preference at top of list; Martin et al. 1951).

North Atlantic Connecticut Excluding Winter	Great Lakes Ohio Year Round	Michigan Winter
Crabgrass	Wheat	Sumac
Bluegrass	Alfalfa	Plantain
Garden crops	Clover	Dogwood
Clover	Soybean	Blackberry
Blackberry	Oats	Yarrow
Plantain	Alsike clover	Cherry
Sheepsorrel	Corn	Elderberry
Panicgrass	Rye	Oak
Gray birch	Bluegrass	Apple
Red maple		
Cherry		

B. Habitat Requirements

Burt (1964)

Heavy brush, strips of forest with open areas nearby, edges of swamps, weed patches and old fields.

C. Population Densities

Burt (1964)

Flucuates from 1 rabbit/4 acres to several/acre.

D. Management Techniques

The most desirable habitat for rabbit is an upland situation, thus appropriate drainage and soil building procedures are required if an inundated or saturated area is used for habitat development. Vegetation may be established by seeding (grass, clover, etc.) along with fertilizer application or by allowing natural succession to occur if suitable species for seed stock are present nearby. Some portions of areas should be allowed to progress to a shrub state to provide nest habitat. Once a desirable habitat has been attained, rabbits can be stocked if not available from the surrounding local habitat. The early successional stage (grass, herb) for foraging must be maintained by burning or mowing. The following plan has been suggested for habitat management (Musser 1963):

1. Establish food strips adjacent to hedgerows, woodland border cuttings, etc., using bluegrass, white clover, timothy, etc., during the spring if possible.
2. Soil tests should be taken to determine lime and fertilizer needs, and proper amounts should be applied.
3. Clear portions of hedgerows, woodland borders, etc. to maintain low ground cover.
4. Food strips should be eight to ten feet wide and should be mowed twice a year to maintain clovers and succulence of vegetation.

Brush piles which could be constructed from vegetative debris after maintenance clearing or trimming of vegetation are also attractive nest sites.

Populations should be controlled by hunting or trapping.

Woodchuck (*Marmota monax*)

A. Food Preferences

Almost completely plant matter.

North Atlantic (Martin et al. 1951)

Clover	Soybeans
Grasses	Alfalfa
Vegetables	Honeysuckle

B. Habitat Requirements

Dry woods and adjacent open areas; brushy ravines, rocky slopes; fields, mowed roadway borders (Collins 1959). Dens are found in dry areas well above the water table and may be in open fields or in shrub areas (Meyers, J. Dames & Moore, personal experience).

C. Management Techniques

Habitats for the woodchuck should be well above the water table. The soil must be dry and well drained for suitable growth of grasses and clover. Planting of grasses and clover between narrow rows of shrubs will produce an ideal habitat and feeding area for woodchuck. Control of succession may be accomplished by mowing sections of the field at different intervals during the growing season. This creates a constant food supply and controlled succession of the plant community.

With favorable habitat available, immigrant woodchuck from established populations should quickly become established in new areas. Research has shown that moderate hunting pressure on a woodchuck population did not significantly reduce the total population. Increased birth and survival rates of young were observed in areas where hunting occurred, and emigration was greater from areas where hunting had been restricted (Davis et al. 1964).

Canada Goose (Branta canadensis)

A. Food Preferences

General food preferences: California rice, safflower, watergrass, milo, alkali bulrush.

Regional preference (Highest preference at top of list; Martin et al. 1951).

Atlantic Coast	Gulf Coast
Cordgrass	Cordgrass
Widgeongrass	Saltgrass
Spikerush	Glasswort
Sea-lettuce	Bulrush
Naiad	Bermudagrass
Glasswort	Naiad
Eelgrass	Matrimony-vine

B. Habitat Requirements

Stewart and Robbins (1958)

1. Shallow water with aquatic vegetation in tidal bays, estuaries, inland ponds and lakes.
2. In many areas, feeds extensively in wheat, rye and corn fields.

C. Management Techniques

In creating the habitat we recommend the habitat should be below the water table and an average water depth of 4 feet should be maintained. Initial planting of corn, wheat and rye in large open flat areas adjacent to the aquatic habitats will attract migrating geese into the area. To establish a resident population one should plant cordgrass, widgeongrass and spikerush in and around the margins of the pond. Natural growth by these plants will create a large feeding area for resident geese. Control of undersirable perennials such as cattail and reed may be accomplished by applying herbicides and controlling the water levels in the aquatic habitat (Widjeskog and Ferrigno 1972).

Artificial nest structures can be used to induce nesting of resident geese and increase nesting density (Bishop and Barratt 1970). These structures can be constructed from large used tires 18" and 25" and a wire basket supported by four posts. The tire is placed inside the wire basket and straw is placed in the tire. These structures are effective nests for the Canada Goose. Another effective nest can be made by constructing mounds of earth in the ponds or aquatic habitat. These mounds should be isolated 2 to 3 feet above the water level, and slightly flat on the top. Fast growing plants should be planted around the mounds to initiate nesting.

Capturing and transplanting native juvenile geese to new areas while still flightless at an age of 7 to 8 weeks has been successful in establishing new populations (Surrendi 1970). A release of game farm geese on an area with suitable habitat has been successful in at least one instance in establishing a new population (Gore and Barstow 1969).

Hunting will control the population after it has been well established in the area. Estimates of the hunting success and geese population levels should be maintained to monitor the population.

Mallard (*Anas platyrhynchos*)

A. Food Preferences

Highest preference at top of list, (Martin et al. 1951).

North Atlantic	South Atlantic	Pacific
Wild rice	Wild millet	Pondweed
Pondweed	Smartweed	Bulrush
Smartweed	Bulrush	Sorghum
Wild celery	Duckweed	Horned pondweed
Wild millet	Spikerush	Wild millet
Naiad	Pondweed	Spikerush
Corn	Wild rice	Muskgrass
Cutgrass		Corn
Oak		Sedge

B. Habitat Requirements

Stewart and Robbins 1958

1. Breeding usually on or near the edges of ponds or streams that are fringed with marsh vegetation.
2. Migratory and wintering-all types of fresh water and tidal ponds, lakes, and streams; also feeds extensively in corn fields located nearby.

C. Population Densities

Maryland - 5.3 breeding pairs/100 acres (Stewart and Robbins 1958)

D. Management Techniques

Impoundments created by diking are suitable for Mallard habitat if food sources are available in the impoundment or neighboring woods. If proper water levels are maintained, water fowl food plants (pondweed, smartweed, and spikerush) should volunteer in the impoundment. High water levels will hamper valuable vegetative establishment and excessive drainage will encourage the establishment of reed which will dominate the area and make it undesirable to the ducks (Widjeskog and Ferrigno 1972). On waterfowl impoundments, treatment of undesirable perennials such as cattail and reed with herbicides and controlled water levels has increased the amounts of important food plants such as spikerush for waterfowl (Widjeskog and Ferringno 1972). Mallard will become established naturally on the impoundment or they may be artificially propagated and stocked. The presence of corn or grain fields near the impoundment is very conducive to duck populations.

The following techniques can increase breeding success of the ducks:

1. The use of hand-reared wild strain Mallard has been successful in increasing populations of nesting ducks on waterfowl areas. However, their ability to survive may be lower than that of wild birds due to a lack of wariness and a tendency to flock (Schladweider and Tester 1972). Breeding density was raised from 12 pairs/square mile in two years (Sellers 1973).
2. Artificial nest baskets have also been used to increase nesting densities of Mallard (Bishop and Barratt 1970).
3. Predator control during nesting periods can successfully increase nesting success of ducks (Schranck 1972).
4. The provision of residual nesting cover adjacent to water resulted in a greater density of nesting pairs, and better nesting success than on areas where mowing of cover occurred (Jarvis and Harris 1971).

Black Duck (*Anas rubripes*)

A. Food Preferences

Adults feed 25% on animal matter including mollusks, crustaceans and immature stages of beetles, bugs and dragonflies; 75% of their diet is plant food including pondweed, wild rice, and cordgrass (Martin et al. 1951; Kortright 1942).

Region preferences of plant food (highest preferences at the top of list).

Northeast	Southeast
Pondweed	Pondweed
Wild rice	Smartweed
Cordgrass	Naiad
Bulrush	Algae
Smartweed	Widgeongrass
Widgeongrass	Spikerush
Bur-reed	Wild rice
Wild celery	Bulrush
Arrowhead	Cordgrass
Eelgrass	
Corn	
Naiad	
Sedge	

B. Habitat Requirements

Freshwater and salt marshes, ponds, swamps, and rivers with sufficient concealment for nesting (Kortright 1942). This species will nest in a variety of situations and does not seem to prefer any particular surrounding, provided it can find sufficient concealment (Bent 1923).

C. Management Techniques

The habitat should be below the water level and the average depth of the water should be 4 feet. The Black Duck is fairly dispersed between salt marshes and freshwater habitats. A majority of the salt marsh habitats for this species is found in the Southeastern United States. The requirements for freshwater habitats are similar to Mallard except that the area should have an abundance of shrub and high grasses for sufficient concealment during nesting.

Pondweed, smartweed, cordgrass, and wild rice should be planted for feeding areas. Shrubs such as alder and buttonbush should be adjacent to the aquatic habitats for possible nesting locations. The undergrowth in the wooded terrestrial habitat should be encouraged by clear cutting small strips to induce a second growth.

Control of succession should be accomplished by strip cutting of woodlots, hand application of herbicides, and controlled burning of mature shrub areas.

Hunting of Black Duck does not significantly reduce its numbers due to the ability of this species to detect human presence and escape the majority of hunters (Kortright 1942).

Wood Duck (Aix sponsa)

A. Food Preferences

Highest regional preference at top of list; Martin et al. 1951

North Atlantic	South Atlantic	Pacific
Wild rice	Oak	Pondweed
Pondweed	Hickory	Bur-reed
Bur-reed	Water-lily	Smartweed
Smartweed	Duckweed	Sedge
Arrow-arum	Manna-grass	Cow-lily
Beech	Ash	Water-lily
Sedge	Blackgum	Dogwood
Duckweed		Nightshade
Cow-lily		Buttercup
Oak		

Fall food preferences in South Carolina included water oak, bald cypress, sweetgum and corn (McGilvrey 1966).

B. Habitat Requirements

Inland pools and streams bordered by woods and forest swamps. Nests primarily in natural cavities in the trunk or large branches of trees (Kortright 1942).

C. Management Techniques

Impoundments created by diking are suitable for Wood Duck habitat if food sources are available in the impoundment or in neighboring woods. If proper water levels are maintained, water fowl plants should volunteer in the impoundment. High water will hamper valuable vegetative establishment (pondweed, smartweed, spikerush) and excessive drainage will encourage establishment of reed which will dominate the area and make it undesirable to the ducks (Widjeskog and Ferrigno 1972). Wood Duck populations will become established naturally or they may be established successfully by artificial propagation and stocking. If wooded areas for nesting are not available nearby, nesting boxes should be provided to encourage nesting on the site.

Nesting boxes have been successfully used to increase the number of nesting sites available on a given area (Doty and Kruse 1972). Nesting houses providing protection from predators increase breeding pairs of ducks (Bellrose et al. 1964).

Wood Duck populations have been successfully established by artificially propagating and releasing young Wood Duck on the area where a nesting population of Wood Duck was desired (Doty and Kruse 1972).

Artificial propagation has also been used to imprint young Wood Duck to utilize nesting boxes in areas where a Wood Duck population already existed (Lane et al. 1968).

Populations can be controlled by hunting.

Muskrat (Ondatra zibethicas)

A. Food Preferences

(Highest regional preference at top of list; Martin et al. 1951; Bellrose 1950)

Great Lakes Illinois	North Atlantic	Pacific	Gulf Louisiana
Cattail	Cattail	Cattails	Bulrush
Pickerelweed	Bulrush	Bulrush	Cattail
Bulrush	Bur-reed	Bur-reed	Panicgrass
Smartweed	Water-starwort	Waterlily	Cordgrass
Water-lily	Pondweed	Willow	Rush
Amer. lotus	Arrowhead	Spikerush	Needlegrass
Black willow	Corn	Horsetail	

B. Habitat Requirements

1. Marshes, edges of ponds, lakes and streams associated with cattails, water-lilies, and open water (Burt 1964).
2. Muskrat houses are generally built in water of 10 to 24 inches in depth, and may also live in burrows in stream and pond banks (Bellrose 1950).
3. Southern limit of coastal form of the muskrat is the Neuse River, North Carolina (Errington 1940).

C. Population Densities

Ferrigno (personal communication)

1. Salt marsh with controlled water levels and vegetation - 12 - 15 muskrat/acre.
2. Open tidal marsh - 6 muskrat/acre is about maximum.

D. Management Techniques

Small impoundments created by flooding, a diked area, or allowing existing water to stand in an area, constitute suitable habitats for muskrat.

Studies have shown that diked areas of marsh where the water level can be controlled produced increased population densities by creating a reduction of mortality. (Donahoe 1966).

In the Northeast, draining the area for a short time to allow reed to become established would create a very successful situation for muskrat houses. However, reed is of poor nutritive value and nearby sources of food as cattail, bulrush, burreed, arrowhead and corn must be available. If areas in any region are kept flooded immediately after spoiling and thereafter, other aquatic plants than reed (cattail, bulrush, burreed and arrowhead) may become established, thus creating an adequate area for houses and a suitable food source in the same diked area. Where sufficient vegetation for food and house material has developed, muskrat can be stocked in the impoundment if not available from a nearby local population by immigration. Proper water level control is important in maintaining muskrat populations. Muskrat populations will be favored where water depth is kept fairly shallow. Deepening stream channels will be unfavorable for aquatic plant growth and for establishment of muskrat houses. (Anthony, personal communication).

Also a proper water level will arrest succession and maintain the impoundment in an appropriate vegetative state. In New Jersey the use of dikes to control water level and retain vegetation which is found near the level of spring tide such as Spartina alterniflora and Spartina patens will improve muskrat habitat. (Ferrigno, personal communication).

Approximately 50 percent of the total population can be removed by trapping each year and still maintain a stable population. (McCann 1944).

Wading Birds - (Order Ciconiiformes)

A. Species Potentially Involved in Habitat Enhancement Programs

1. Little Blue Heron
2. Louisiana Heron
3. Green Heron
4. Black-crowned Night Heron
5. Yellow-crowned Night Heron
6. Great Egret
7. Cattle Egret
8. Snowy Egret
9. Glossy Ibis
10. White Ibis
11. Great Blue Heron

B. Food Preferences

All of the above species except for the Cattle Egret, Yellow-crowned Night Heron, Glossy Ibis and White Ibis show a strong preference for fishes, amphibians (mainly frogs), aquatic insects, etc. The Cattle Egret feeds primarily in upland habitats where it consumes terrestrial arthropods, arachnids, and amphibians. The Yellow-crowned Night Heron, and Glossy and White Ibises utilize crustaceans (often crayfish) for food most frequently (Palmer 1962).

C. Habitat Requirements

Feeding for these species occurs in shallow waters. There exist some "preferences" as to marine, brackish, or fresh water by certain species mentioned. The shallow waters may extend over a wide area or be restricted to shorelines. The Green Heron for example rarely ventures out into open shallow water for feeding. It usually restricts itself to pond or water course margins. The water bodies require "preferred" food items in terms of appropriate sizes and abundance. Pasture lands would be suitable for Cattle Egret feeding.

Nesting by these colonial species occurs under two general environmental conditions. Colonies are situated 1) in trees, bushes or reeds surrounding a water body and 2) in trees, bushes or reeds surrounded by a body of water. Feeding grounds must be within a few miles (probably less than 5-6 miles from the colony site). These species infrequently feed in the immediate vicinity of the colony. The Cattle Egret tends to require an existing and functioning colony for nesting. Other species may additionally need this stimulus but perhaps to a lesser degree.

D. Management Techniques - Management schemes will be most successful in Costal Plain habitats

1 - Feeding grounds for aquatic feeding species can be provided by developing a basin capable of holding waters to a depth of about a meter with gently sloping bottom topography. Occasional islands of at least an acre in size should be prepared which should be planted and maintained in a shrub or young hardwood condition. This vegetation would be used in roosting sites. If nesting was initiated, some shrubbery would be needed as nest material in addition to use as nest sites. The shrubbery should be most dense at the edges of the hammock with the interior kept relatively free from emergent undergrowth. To facilitate use of the disposal site for nesting by these birds the islands should be partitioned to allow the management of understory characteristics by proper timing an amount of disposal material

additions. Human intrusion should be minimized during the reproductive season (March through August). Some predator control may be needed such as removal of raccoons and mink.

2 - Stock aquatic disposal area with suitable fish, crustacean species and amphibians if possible so that relatively high densities may be obtained.

3 - Minimize human intrusion from March to July, particularly during the initial years of the colony.

Miscellaneous Shorebirds (Order Charadriiformes)
(Bent 1927, 1929)

Bird	Food	Feeding Habitat
Short-billed Dowitcher	Grasshoppers, beetles, flies, maggots, marine worms	mud flats & sand flats in sheltered bays & estuaries; borders of shallow ponds or marshes
Long-billed Dowitcher	midge larvae	marshes
Knot	minute mollusks, small crustaceans	sandy and stony beaches
Least Sandpiper	insects, larvae, crustaceans, worms	tidal flats, salt marshes beaches
Dunlin	mollusks, worms, crustaceans, insects, spiders	mud
Semipalmated Sandpiper	New England - insects, small mollusks, worms, crustaceans Alabama - mollusks, fly larvae, beetles	beaches, sand flats of tidal estuaries
Western Sandpiper	probably same as other small sandpipers Alabama - fly larvae, aquatic beetles and bugs, marine worms	same as above
Sanderling	sand fleas, shrimps and other small crustaceans, small mollusks	beaches
Hudsonian Godwit	worms, insects, mollusks, crustaceans	
Greater Yellowlegs	small minnows, water insects	shallow water
Lesser Yellowlegs	insects, small crustaceans, small fishes, worms	flat marsh near coast; wet, short-grass marshes, mud flats, shallow ponds
Snowy Plover	crustaceans, marine worms	sand flats

Management Techniques - Shorebirds

Alternative 1

A basin with shallow water (up to 0.5 meter) is required. Suitable food items should be introduced along with dredged material so no additional stocking effort should be required.

Alternative 2

The site sediment can be treated to allow grass seed growth. Grazing by large herbivores (ungulates) will allow shorebirds feeding habitat to develop. This alternative would work best where rainfall is relatively high and/or the surface sediments can be maintained relatively moist. Situations like this exist along very high marsh and grassland habitats along the intracoastal waterways in Georgia (e.g. Ossabaw Island area).

Black-necked Stilt (*Himantopus mexicanus*)

A. Food Preferences

The Black-necked Stilt feeds mainly on insects, aquatic bugs and beetles; also on dragonfly nymphs, caddis flies, mayfly nymphs, flies, pillbugs, mosquito larvae and grasshoppers.

B. Habitat Requirements

Preferred feeding habitat consists of wet meadows, or shallow ponds with water between small turfs of grass. Nesting occurs above high water in wet meadows, and in mounds in or at edge of very shallow ponds.

C. Breeding Range

The breeding range extends north to Oregon, Utah, Colorado, Louisiana and Florida (Pough 1951).

D. Management Techniques

For feeding habitat provide a pond with a shallow depth of 4-5 inches and a silty sand substrate.

For nesting, add small mounds in wet meadows or very shallow ponds (see above). The mound height may be few inches above high water levels.

American Avocet (Recurvirostra americana)

A. Food Preferences

The food consists primarily of phyllopods, dragon fly nymphs, black skimmers, seeds of marsh and aquatic plants.

B. Habitat Requirements

Feeding is done primarily in muddy pools.

Avocets nest on dry, sun-baked mud flats or low, gravelly or sandy islands with scant vegetation.

C. Breeding Range

The breeding range extends from Washington east to Wisconsin, south to Texas and North Carolina.

D. Management Techniques

For feeding habitat, provide a shallow pond 4" - 14" in depth and eutrophicate it with fertilizer, etc.

For nesting, provide habitat with characteristics described above under "Habitat Requirements".

Herring Gull (*Larus argentatus*)

A. Nesting Requirements

The herring gull breeds in small or large colonies but always in the neighborhood of some body of water - river, lake or the sea. Their nests can be found at the foot of stumps or over-hanging rocks or drift-wood. They also nest on ledges on cliff faces and in the ground in thick spruce woods. Nests have been found in other scattered locations and even in trees. The nest can be very simple hollows lined with grasses or sticks or very well structured with interwoven grasses and feathers (Bent 1921). The most important requirements are open land for nesting and a nearby body of water for feeding purposes (Bent 1921).

B. Management Techniques

Island habitats should satisfy the above requirements best. Colony establishment may be difficult until grasses and some shrubbery develop. Once this occurs, it should be kept in an early stage of succession with numerous barren or open areas. Translocation of advanced or near fledgling young should be tried to accelerate colony formation. The proximity of nesting habitats to garbage dumps, fishing disposal wastes, etc. will likely increase chances of success for establishing a colony (Pough 1951).

Ring-billed Gull (*Larus delawarensis*)

A. Nesting Requirements

Nests are built in hollows among the rocks or tree stumps but normally on the ground. Materials of local abundances such as grasses, masses of sticks or breast feathers are used. It always nests in close association with some body of water (Bent 1921). The presence of nesting areas near a water body containing a food supply is the basic requirement for this species (Bent 1921).

B. Management Techniques

This species nests in the northern portion of the North Atlantic Region and in the Great Lakes Region. Management procedures, etc. are similar to those for the Herring Gull (Page C42).

Laughing Gull (*Larus atricilla*)

A. Nesting Requirements

Laughing Gull live close to the sea. They nest in salt marshes and among the grasses on sand dunes and on sandy reefs and islands. The nests themselves are sometimes a hollow in the sand lined with grass and sticks or may be more elaborately made structures of various coarse dry grasses firmly interwoven and built up above the sand (Bent 1921).

B. Management Techniques

Island habitats with the above characteristics suitable for nesting are needed. Translocating fledglings or advanced nestlings should facilitate colony establishment.

Common Tern (*Sterna hirando*)

A. Nesting Requirements

Tern nests are a slight depression in a sand or a pebble beach. The windrows of seaweed or dry eelgrass, just above high-water mark, are often used as nesting sites (Bent 1921). The common tern is an aquatic bird spending most of its time near and over the sea. Nesting is on sandy dunes and islands along the coast (Bent 1921) in isolated areas (Pough 1951). In some areas the only surviving colonies are on spoil-banks created by dredging operations (Pough 1951).

B. Breeding Range

This species nests along the Atlantic coast and inland to northern Pennsylvania.

C. Management Techniques

Isolated sandy islands should be kept relatively free from vegetation. Dikes should be high enough to keep all but most severe storm tides from inundating the nesting area. Rodent and medium sized mammal trapping may be needed because the Norway rat, foxes, skunks, raccoons, weasels, cats and dogs can be disastrous to a colony (Pough 1951). Human intrusion should be kept to a minimum also. Trapping should be done prior to the breeding season and if needed during it.

Roseate Tern (*Sterna dougallii*)

A. Nesting Requirements

Nests of the Roseate Tern are mostly well concealed in thick growths of tall beach grass, vines and other dense cover. The eggs, however, are often laid on bare ground. A scanty nest is sometimes formed from pieces of dry grass or debris (Bent 1921). Roseate Tern lives along maritime water. Its nests are on rocky, pebbly or sandy low islands along the coast giving it easy access to the bays, channels, inlets and open water (Bent 1921; Pough 1951).

B. Breeding Range

This species has nested in the North Atlantic, South Atlantic and Gulf Regions (Pough 1951).

C. Management Techniques

See those for Common Tern (Page C45).

Caspian Tern (Hydroprogne caspia)

A. Nesting Requirements

Nests are made either of a few sticks and a little grass or straw or are simply a depression in sand, gravel or decaying vegetation. These birds normally nest in habitats similar to that of gulls and other terns but it frequently separates itself from them and nests in an isolated group. It is easily disturbed by human intrusion (Bent 1921). Its feeding habits are basically aquatic. The Caspian Tern nests and lives in close proximity to the sea. Most of its nests are on the low, brushy sand islands along the coast (Bent 1921).

B. Breeding Range

It nests along the Atlantic coast, in the Great Lakes area, Gulf coast and southward from central lower California (Pough 1951).

C. Management Techniques

Techniques are similar to that of the Common Ten. (Page C45).

Gull-billed Tern (Gelochelidon nilotica)

A. Nesting Requirements

The Gull-billed Tern formerly nested in salt-marshes. It now nests on sand dunes where nests are well hidden among the shell fragments, rock and pebbles (Bent 1921). It also nests on low grassy marsh islands where eggs are laid on the ground or on matted grasses (Pough 1951). This species, unlike many other terns, is largely insectivorous spending much of its time over salt marshes and fields, taking large numbers of spiders, grasshoppers, beetles and some frogs, crabs and fish (Bent 1921).

B. Breeding Range

Nesting by this species occurs along the coast from south New Jersey to the Gulf of Mexico and in the southern California coast.

C. Management Techniques

Techniques similar to those used for the Common Tern (Page C45) should be used.

Royal Tern (*Thalasseus maximus*)

A. Nesting Requirements

Nests are a depression in the sand, located in densely packed colonies on sandy islands and dunes along the coast (Bent 1921). Feeding is almost entirely on small fish. It often associates with other species such as the Black Skimmer, Sandwich Tern and Laughing Gull (Bent 1921).

B. Breeding Range

It breeds from Virginia to Texas along the coast (Pough 1951).

C. Management Techniques

Techniques similar to that of the Common Tern (Page C45) should be used.

Forester's Tern (*Sterna forsteri*)

A. Nesting Requirements

The Forester's Tern places its nests in the sand, grass and ocean debris such as dead sedges, sea weeds and oyster shells. The nests are large and elaborate structures. They consist of large piles of dead sedges and grasses surmounted by neat, deeply hollowed nests with well-rounded and compactly woven rims (Bent 1921). Most of its time is spent nesting and feeding along the marshes. It eats insects, fish, frogs, etc., captured from the waters surface (Bent 1921).

B. Breeding Range

Its breeding range involves the Atlantic Coast south from Maryland to the Gulf coast, central California south and Great Lakes area (Pough 1951).

C. Management Techniques

Techniques similar to those employed for the Common Tern should be used except vegetation need not be removed, diking is unnecessary.

Least Tern (*Sterna albifrons*)

A. Habitat Requirements

Nests are merely small hollows scooped in the sand (Bent 1921). The Least Tern breeds on broad flat open sand beaches, entirely devoid of vegetation, where small stones and bits of shells are scattered. The eggs are usually laid well above the reach of the mean high tide.

The breeding areas are frequently found on the beaches and dredged disposal if they are not near human habitations (Bent 1921).

B. Breeding Range

This species nests along the Atlantic Coast from the Cape Cod area south to Florida and along the Gulf Coast (Bent 1921).

C. Management Techniques

Least Terns utilize areas which would be managed in a manner similar to Common Terns. This species however nests on non-island sandy areas including development spoil material, dredged material, causeways etc.

Black Skimmer (*Rynchops nigra*)

A. Food Preferences

Food of the Black Skimmer consists mainly of small fish, and to some extent shrimps and other small crustaceans. It feeds largely on the wing by skimming close to the smooth water, cutting the water's surface, with its lower mandible, from which it scoops into its mouth any animal food to be found there (Bent 1921).

B. Nesting Requirements

Black Skimmer colonize the sand flats where there are numerous oyster, clam and scallop shells scattered about. They half bury their eggs in the sand where they are not conspicuous (Bent 1921).

C. Habitat Requirements

Black Skimmer inhabit the low islands along the coast and nest along beaches and sand flats. Their feeding time is spent over the open waters of the coast and in the mud flats and shallows (Bent 1921).

Bluegill (*Lepomis macrochirus*)

A. Food Preferences

As bluegill increases in size, their prey preferences tend to increase in size. Initially zooplankton and aquatic insects are consumed. As they grow, small fish, fish eggs, snails, mollusks, mites, small crayfish, and amphipods become important (Harlan and Speaker 1956; Bennett 1948; DiCostanzo 1957; Huish 1958; Leonard 1940; Lux and Smith 1960; Scidmore and Woods 1960; Seaburg & Moyle 1964; Whitmore et al. 1960).

B. Habitat Requirements

Bluegill thrive in still or sluggish waters. They prefer protected areas with clear quiet water, scattered beds of vegetation and a bottom of sand, gravel, or muck (Trautman 1957; Hubbs and Lagler 1958). They grow best at temperatures between 60 and 80° F (Trautman 1957) but can survive temperatures of 95°F (Rounsefell and Everhart 1953).

C. Nesting Requirements

Nests are built in sand, gravel, dead leaves, sticks or mud. Water from 2 to 6 feet in depth is preferred (Calhoun 1966).

D. Population Densities

The yield in New York farm ponds was reported to range from 40.0 to 315.0 pounds / surface acre (Regier 1963).

E. Management Techniques

Stocking of 500 to 1000 bluegill per acre is recommended (Regier 1963).

Largemouth Bass (*Micropterus salmoides*)

A. Food Preferences

As the size of the largemouth bass increases, so does its choice of prey. Fry feed primarily on small crustacean genera including cyclops and *Daphnia* (Calhoun 1966). Juveniles consume insects and adults feed primarily on fish, with worms, mussels, frogs, crayfish, snails, and large insects also forming a portion of the diet (Ewers and Boesel 1935; Harlan and Speaker 1956).

B. Habitat Requirements

They prefer nonflowing, clear waters which contain aquatic vegetation (Trautman 1957). The fish are generally located near weed beds, submerged trees and other obstructions (Caine 1949). Preferred bottom types are soft muck and organic debris, gravel, sand, and hard nonflocculent clays (Trautman 1957).

C. Nesting Requirements

A substrate such as sand, gravel, roots, or aquatic vegetation is required (Curtis 1949; Simon 1951), at a medium depth of 30 inches (Kramer and Smith 1962).

D. Population Densities

Standing crops of largemouth bass vary from 6.6 to 23.7 pounds per surface acre (Calhoun 1966).

E. Management Techniques

Stocking 100 largemouth fry per acre is recommended (Regier 1963). Temperatures of about 80°F. are most suitable (Dendy 1948) while respiration becomes difficult at 86°F. (Johnson and Charlton 1960).

Channel Catfish (Ictalurus punctatus)

A. Food Preferences

Channel catfish are omnivorous and consume a wide variety of foods (Bailey and Harrison 1948). Insects are the primary food of young, with small fish and plant seeds included. Adults feed primarily on fish, larger insects and plant material. In contrast, Menzel (1945) found filamentous algae as a dominant food source for adult channel catfish.

B. Habitat Requirements

Although native to flowing water systems, channel catfish also live in sluggish streams and reservoirs (Calhoun 1966). They prefer warm water, and do not grow well at temperatures less than 70°F (Macklin and Soule 1964; McCammon and LaFrance 1961). They are also very tolerant of high turbidity; Wallen (1951) found 85,000 ppm turbidity to be the fatal level. This is, however, seldom reached under natural conditions. Moss and Scott (1961) also found that channel catfish gradually acclimatized could survive at dissolved oxygen levels less than 1 ppm.

C. Nesting Requirements

Channel catfish usually spawn at secluded protected sites such as in holes and under rocks (Brown 1942; Davis 1959; Harlan and Speaker 1956). Geibel and Murray (1961) also found that nests were made in the open on muddy bottoms at fisheries ponds.

D. Population Densities

Calhoun (1966) found that standing crops of channel catfish are usually less than 25 pounds per acre. His observations were made from 19 studies.

E. Management Techniques

New or reclaimed ponds, when properly fertilized, are initially planted with channel catfish fingerlings at a rate of 50 fish per acre in combination with largemouth bass and bluegill (Finnel and Jenkins 1954). However, channel catfish normally will not reproduce in clear ponds or lakes unless artificial spawning devices are added (Marzolf 1957). Restocking may be necessary if survival rates are low because of predation (Calhoun 1966). Marzolf (1957) also indicates that heavy vegetation growth is detrimental to survival because it often harbors predaceous insects.

Swamp Rabbit (*Sylvilagus aquaticus*)

A. Food Preferences

Swamp rabbi's prefer emergent aquatic vegetation and succulent herbaceous vegetation, such as grass, sedges, and cane (Golly 1962).

B. Habitat Requirements

1. Water is generally included in its range (Golly 1962).
2. Two types of shelter are required:
   a. Adults require resting places called forms, which are often located on tops of old stumps, in low crotches of trees, in honeysuckle tangles and in cane patches.
   b. The shelter for the nest is under honeysuckle or other suitable thickets (Golly 1962).

C. Population Densities

A population of one swamp rabbit per seven acres of poorly drained bottomland was estimated on the Gulf coast in Texas (Davis 1966).

D. Management Techniques

This rabbit is a good game species and desired population levels can be maintained by hunting.

Marsh Rabbit (*Sylvilagus palustris*)

A. Food Preferences

Marsh rabbits feed on various marsh vegetation including rhizomes and bulbs.

Marsh rabbits eat a variety of herbaceous foods, including marsh grass, cane, forbs, leaves of deciduous trees, and shrubs (Golly 1962).

B. Habitat Requirements

Low coastal areas, brackish marshes and flood plains are common habitats for marsh rabbits. Thickets are also desirable for shelter (Golly 1962).

C. Population Densities

In favorable habitat this species may become quite abundant (Golly 1962).

D. Management Techniques

This rabbit is a good game species and desired population levels can be maintained by hunting.

Osprey (*Pandion haliaetus*)

A. Food Preferences

1. The diet of this species consists entirely of fish (Fisher 1893).

2. The following species have been recorded in its food: herring, bluefish, blowfish, bonito, bowfin, carp, catfish, eel, flounder, flying fish, goldfish, hornpout, menhaden, mullet, perch, pickeral, pike, salmon, shad, squiteque, sucker, sunfish, tom cod, trout, whitefish (Bent 1937).

B. Habitat Requirements

Ospreys nest in secure places near good food supplies, and do not havr a preference for any species of tree or any particular height in trees (Bent 1937). They have frequently nested on dead trees and poles (Bent 1937).

C. Population Densities

Osprey will nest in concentrated groups if there is a plentiful food supply in the area.

D. Management Techniques

Artificial nesting structures have been used successfully in attracting breeding ospreys (S. Postupalsky, verbal communication). This structure is a flat circular platform supported by four 15 to 20 foot poles. The platform has dowel rods on the edge to support the nest in its primary state.

Common Snipe (Capella gallinago)

A. Food Preferences

1. Animal matter consists of 5 to 22% of the diet for the entire year. This diet contains fly larvae, beetles (especially aquatic forms), crustaceans, earthworms, fresh-water snails and small fishes (Martin et al. 1951).

2. Vegetable matter (highest preference at top of list) (Martin et al. 1951)

Pacific Northwest

Bulrush
Sedge
Burreed
Sunflower
Bogbean
Smartweed
Wildmillet
Bristlegrass

B. Habitat Requirements (Oregon State Game Commission 1972)

Marshes or coastal flats covered with low vegetation.

C. Management Techniques

1. Coastal flats will develop naturally on some spoil sites.

2. Relatively poor soil drainage is required to maintain a moist but not continually inundated environment.

3. Since the common snipe is a naturally occurring species, it will use the area when the correct habitat develops.

Blacktail Deer (*Odocoileus columbianus*)

A. Food Preferences (Brown 1961)

Vegetable matter (highest preference at top of list)

Trailing Blackberry
Salal
Red Alder
Vine Maple
Western Hemlock
Douglas Fir
Huckleberry
Western Red Cedar
Apple
Willow
Salmonberry
Cranberry
Poplar
Dogwood
Western Thimbleberry
Oregon Grape

B. Habitat Requirements (Brown 1961)

Prefers the brushy, logged-over lands and Douglas fir forest.

C. Population Densities (Brown 1961)

1. 10 to 26 deer per square mile (on a range).
2. 10 per square mile in mature forests.
3. 26 per square mile in 5 to 10 year old cutover forests.

D. Management Techniques

Maximum holding capacities for deer are accomplished by cutting of selected areas of forest or controlling developing forest, thus increasing the amount of browse for deer. Surplus populations are necessary for introduction of hunting. Hunting of both sexes may be necessary to control overpopulation.

Brush Rabbit (*Sylvilagus bachmani*)

A. Food Preferences

Forbs and grasses (Ingles 1965)

B. Habitat Requirements (Burt 1964, and Ingles 1965)

1. Heavy brush and cover are necessary for protection from severe weather and predators.
2. Scattered openings with grass and forbs are necessary for feeding. Brush cover should always be in close proximity to feeding areas.

C. Population Densities (Burt 1964)

1 to 3 per acre with a home range of 1/4 to 1 acre.

D. Management Techniques

Since this species does not burrow, shrubs and thickets are definite requirements. The best plan is to establish strips of grasses and forbs between shrub areas. Grasses should be maintained by periodic mowing. Shrub areas should be maintained by hand-applied herbicides or selective cutting.

Populations should be controlled by hunting when a surplus population develops.

American Wigeon (*Anas americana*)

A. Food Preference (highest preference at the top of the list) (Martin et al. 1951)

Pacific

Pondweed
Widgeongrass
Spikerush
Algae
Alfalfa
Eelgrass
Bullrush
Wild Millet
Water Milfoil

B. Habitat Requirements

Wild open marshes and upland grasslands are necessary food and feeding areas. Nesting habitats must have tall rank grass or other vegetation for sufficient cover, and also must be located near water (Pough 1951).

C. Management Techniques

The marsh habitat should be maintained at shallow depths, approximately 4 feet, to encourage growth of the staple foods, pondweed and widgeon grass. Upland areas should be planted in strips of alfalfa and tall grasses to provide both feeding and nesting habitat. It is essential to have well-drained soil in the upland area to maintain a relatively dry condition for nesting habitat.

Pintail (*Anas acuta*)

A. Food Preferences (Martin et al.,1951)

Pacific

Pondweed
Bulrush
Wild Millet
Widgeon Grass
Smartweed
Spike Rush
Barley

B. Habitat Requirements (Pough 1951)

Feeding habitat includes upland fields where waste grain is consumed. Tidal flats and brackish marshes are also used in addition to their usual shallow fresh water feeding areas.

C. Management Techniques

Marsh habitats should have a water depth of 2-4 feet and be maintained as such to encourage growth of the above mentioned aquatic plants. Upland areas should be planted in grain crops.

Shoveler (*Anas clypeata*)

A. Food Preferences

About 25% of the Shoveler's food consists of animal matter: mollusks, aquatic insects and crustaceans (Martin et al. 1951, Bent 1923).

The plant food preference in the Southeast is (highest preference at the top of the list):

Bulrush
Pondweed
Algae
Waterlily
Sawgrass
Duckweed
Spikerush
Widgeongrass
Wildmillet

B. Habitat Requirements

Freshwater marshes, sloughs and ponds are habitat for Shoveler. The species will nest on high ground, occasionally far from water but preferably in the tall grass at the edges of sloughs and ponds (Kortright 1942).

C. Management Techniques

Impoundments created by diking are suitable Shoveler habitat if the water level is properly maintained (see Mallard - page C27). Vegetation such as bulrush, pondweed and wildmillet should colonize the edges of the impoundment naturally or they may be artificially propagated. Allowing vegetation to remain dense on the edges of the water will encourage nesting.

APPENDIX D

COMMON AND SCIENTIFIC NAMES OF ORGANISMS MENTIONED IN TEXT AND APPENDIXES

List of Plants

Common Name	Scientific Name
Alder	Alnus spp.
Alfalfa	Medicago sativa
Ailigator weed	Alternanthera philoxeroides
Alsike clover	Trifolium hybridum
American beech	Fagus grandifolia
American chestnut	Castanea dentata
American elm	Ulmus americana
American lotus	Nelumbo lutea
Apple	Pyrus spp.
Arbor vitae	Thuja occidentalis
Arrow-arum	Peltanda sp.
Arrowhead	Sagittaria sp.
Arrow wood	Vibirnum dentatum
Ash	Fraxinus spp.
Aspen	Populus tremuloides
Aster	Aster spp.
Autumn olive	Eleagnus umbellata
Avens	Geum sp.
Bald cypress	Taxodium distichum
Balsam	Family: Balsaminaceae
Barley	Hordeum spp.
Bayberry	Myrica pennsylvanica
Beachgrass	Ammophila arenaria

List of Plants (Continued)

Common Name	Scientific Name
Beans	Family: Leguminosae
Beard grass	*Andropogon* spp.
Beauty-berry	*Callicarpa americana*
Beavertail cactus	*Opuntia* sp.
Beech	*Fagus grandifolia*
Beggarweed	*Desmodium tortuosum*
Bermudagrass	*Cynodon dactylon*
Bicolor lespedeza	*Lespedeza bicolor*
Birch	*Betula* spp.
Birdsfoot-trefoil	*Lotus corniculatus*
Bitternut hickory	*Carya cordiformis*
Bittersweet	*Celastrus scardens*
Black ash	*Fraxinus nigra*
Blackberry	*Rubus* spp.
Black cherry	*Prunus serotina*
Black grass	*Juncus gerardi*
Black gum	*Nyssa sylvatica*
Blackjack oak	*Quercus marilandica*
Black oak	*Quercus velutina*
Black rush	*Juncus roemarianus*
Black spruce	*Picea mariana*
Black willow	*Salix nigra*
Blueberry	*Vaccinium* spp.
Blue Grama	*Bouteloua gracilis*

List of Plants (Continued)

Common Name	Scientific Name
Bluegrass	*Poa* spp.
Bogbean	*Menyanthes* sp.
Box elder	*Acer negundo*
Brass buttons	*Cotula coronopifolia*
Bristlegrass	*Setaria magna*
Broom sedge	*Andropogon virginicus*
Buckwheat	*Fagopyrun esculentum*
Buffalo burr	*Solanum rostratum*
Bulrush	*Scirpus* spp.
Bur-reed	*Sparganium* spp.
Bush clover	*Lespedeza* spp.
Butterfly bush	*Buddleja davidi*
Buttonbush	*Cephalanthus occidentalis*
Cactus	*Opuntia* sp.
California bay	*Umbellularia california*
California cordgrass	*Spartina foliosa*
Canada fleabane	*Conyza canadensis*
Cane	*Arundinaria* spp.
Cattail	*Typha* spp.
Cedar	*Juniperus* spp.
Chaparral broom	*Baccharis piluleris*
Cherry	*Prunus* spp.
Clover	*Trifolium* spp.

List of Plants (Continued)

Common Name	Scientific Name
Clover, Alsike	*T. hybridum*
Coast alkaligrass	*Puccinellia* spp.
Coast Redwood	*Sequoia Sempervirens*
Cocklebur	*Xanthium* sp.
Coco, Bulrush	*Scirpus robustus*
Common elder	*Sambucus canadensis*
Common groundsel	*Senecio vulgaris*
Common horsetail	*Equisetum arvense*
Common reed	*Phragmites communis*
Cordgrass	*Spartina* spp.
Corn	*Zea mays*
Cotton	*Gossypium* spp.
Cottonwood	*Populus deltoides*
Cow-lily	*Nuphar* spp.
Cow-pea	*Vigna sinensis*
Crabapple	*Malus* spp.
Crabgrass	*Digitaria* spp.
Cranberry	*Vaccinium* spp.
Crowfoot-grass	*Dactyloctenium* sp.
Curly dock	*Rumex crispus*
Cutgrass	*Leersia* spp.
Cypress	*Taxodium* spp.
Daisy	Family: Compositae

List of Plants (Continued)

Common Name	Scientific Name
Dandelion	*Taraxacum* spp.
Dock, Sorrel	*Rumex* sp.
Dodder	*Cuscuta indecora*
Dogfennel	*Eupatorium capillifolium*
Dogwood	*Cornus* spp.
Douglas fir	*Pseudotsuga menziesii*
Doveweed	*Croton* sp.
Duckweed	*Lemna* spp.
Early hairgrass	*Aira praecox*
Eelgrass	*Zostrea* sp.
Elder	*Sambucus* spp.
Elderberry	*Sambucus* spp.
Elm	*Ulmus* spp.
English plantain	*Plantago lanceolata*
Fescue-grass	*Festuca* sp.
Fleabane	*Erigeron* spp.
Fleabane	*Pulicaria dysenterica*
Flowering dogwood	*Cornus florida*
Frankenia	*Frankenia grandifolia*
Fresh-water cordgrass	*Spartina pectinata*
Giant bur-reed	*Sparganium eurycarpum*
Glasswort	*Salicornia* spp.
Glasswort, Pickleweed	*S. virginica*
Golden aster	*Chrysopsis* sp.

List of Plants (Continued)

Common Name	Scientific Name
Goldenrod	*Solidago* spp.
Grand fir	*Abies grandis*
Grape	*Vitis* spp.
Gray birch	*Betula populifolia*
Gray dogwood	*Cornus paniculata*
Greenbrier	*Similax* spp.
Groundsel, baccharis	*Baccharis halimifolia*
Gumweed	*Grindelia integrifolia*
Hackberry	*Celtis* spp.
Hawthorn	*Crataegus* spp.
Hazelnut	*Corylus americana*
Hemlock	*Tsuga* spp.
Hickory	*Carya* spp.
Honeysuckle	*Lonicera* sp.
Horned pondweed	*Zannichellia palustris*
Horsetail	*Equisetem* sp.
Huckleberry	*Gaylussacia* sp.
Italian rye grass	*Lolium multiflorum*
Japanese honeysuckle	*Lonicera japonica*
Jasmine	*Gelsemium* sp.
Jaumea	*Jaumea carnosa*
Jerusalem-cherry	*Solanum pseudo-capsicum*
John foxtail	*Setaria magna*
Kentucky bluegrass	*Poa pratensis*

List of Plants (Continued)

Common Name	Scientific Name
Knotweed	*Polygonum* sp.
Korean lespedeza	*Lespedeza stipulacea*
Lespedeza	*Lespedeza* sp.
Loblolly pine	*Pinus taeda*
Lodgepole pine	*Pinus contorta*
Long leaf pine	*Pinus palustris*
Magnolia	*Magnolia* sp.
Maidencane	*Panicum hemitamon*
Manna-grass	*Glyceria* spp.
Maple	*Acer* spp.
Maritime Peavine	*Lathyrus japonicus*
Marsh aster	*Aster tenuifolius*
Marsh elder	*Iva frutescens*
Marsh-grass	*Spartina* spp.
Matrimony-vine	*Lycium* spp.
Meadowgrass	*Poa* sp.
Mesquite	*Prosopis chilensis*
Milk-pea	*Galactia* sp.
Milkweed	*Asclepias* sp.
Mountain laurel	*Kalmia latifolia*
Muhlenbergia	*Mulenbergia* spp.
Multiflora rose	*Rosa multiflora*
Muskgrass	*Chara* spp.
Myrtle	*Vinca minor*

List of Plants (Continued)

Common Name	Scientific Name
Naiad	*Najas* spp.
Needlegrass	*Stipa* spp.
Northern red oak	*Quercus borealis*
Norway spruce	*Picea abies*
Oak	*Quercus* spp.
Oats	*Avena* sp.
Olney's threesquare	*Scirpus olneyi*
Oregon grape	*Berberis nervosa*
Overcup oak	*Quercus lyrata*
Oyster grass, Smooth cordgrass	*Spartina alterniflora*
Panicgrass	*Panicum* sp.
Partridge-pea	*Chamaechrista fasiculata*
Pearly-everlasting	*Anaphalis margaritacea*
Pickerelweed	*Pontederia* sp.
Pickleweed, Glasswort	*Sanicornia* spp.
Pigweed	*Amaranthus* sp.
Pine	*Pinus* spp.
Plantain	*Plantago* spp.
Plum	*Prunus* sp.
Poison Ivy	*Toxicodendron radicans*
Pokeweed	*Phytolacca* sp.
Pondweed	*Potamogeton* spp.
Poplar	*Populus* sp.
Port oxford cedar	*Chamaecyperis lawsoniana*

List of Plants (Continued)

Common Name	Scientific Name
Post oak	Quercus stellata
Prickly pear cactus	Opuntia spp.
Pussytoes	Attennaira sp.
Quaking aspen	Populus tremuloides
Rabbitfoot polypogon	Polypogon monspeliensis
Ragweed	Ambroisa sp.
Ragwort	Senecio glabellus
Red Alder	Alnus rubra
Red clover	Trifolium pratense
Red maple	Acer rubrum
Red mulberry	Morus rubra
Red oak	Quercus rubra
Red pine	Pinus resinosa
Red spruce	Picea rubens
Red top	Agrostis alba
Reed	Phragmites communis
Reed canary grass	Phalaris arundinacea
Reed grass	Family: Compositae
Rice cutgrass	Leersia sp.
Rush	Juncus sp.
Russian thistle	Salsola kali
Rye	Secale cereale
St. Augustine grass	Stenotaphrum secundatum

List of Plants (Continued)

Common Name	Scientific Name
Sagebrush	*Artemesia* spp.
Salal	*Gaultheria shalon*
Salmonberry	*Rubus spectabilis*
Saltgrass	*Distichlis* sp.
Saltmarsh bulrush	*Lythrum lineare*
Saltmeadow cordgrass	*Spartina patens*
Salt reed-grass	*Spartina cynosuroides*
Saltwort	*Batis maritima*
Sassafras	*Sassafras* sp.
Sawgrass	*Cladium jamalcense*
Scotch pine	*Pinus sylvestris*
Scot's broom	*Cystisus scoparius*
Scrub oak	*Quercus ilicifolia*
Sea lavender	*Limonium* sp.
Sea-lettuce	*Ulva* sp.
Sea ox-eye	*Borrichia frutescens*
Sea rocket	*Cakile edentula*
Seashore lupine	*Lupinus littoralis*
Seashore salt grass	*Distichlis spicata*
Seaside goldenrod	*Solidago mexicana*
Sedge	Family: Cyperaceae
Sedge	*Carex* sp.
Shagbark	*Carya ovata*
Sheepsorrel	*Rumex acetosella*

List of Plants (Continued)

Common Name	Scientific Name
Silky dogwood	*Cornus amonum*
Sitka spruce	*Picea sitchensis*
Skunkcabbage	*Sympholocanpus foetidus*
Slash pine	*Pinus caribaea*
Smartweed	*Polygonum* spp.
Smooth cordgrass	*Spartina alterniflora*
Smooth sumac	*Rhus glabra*
Solanum	*Solanum* sp.
Sorghum	*Sorghum* spp.
Sorrel	*Rumex* spp.
Southern red oak	*Quercus falcata*
Sow thistle	*Sonchus asper*
Soybean	*Soja max*
Spikerush	*Eleocharis* spp.
Spiny-leaved sow thistle	*Sonchus asper*
Spiny-sow thistle	*Sonchus asper*
Spotted cat's ear	*Hypochoeris radicata*
Spruce	*Picea* sp.
Spurge	*Euphorbia* sp.
Staghorn sumac	*Rhus typhina*
Strawberry	*Fragaria* sp.
Sugarberry	*Celtis laevigata*
Sugar maple	*Acer saccharum*
Sumac	*Rhus* sp.

List of Plants (Continued)

Common Name	Scientific Name
Sunflower	*Helianthus* sp.
Swamp black gum	*Nyssa sylvatica*
Swamp privet	*Forestiera acuminata*
Swamp red oak	*Quercus falcata* var. *pagodaefolia*
Sweetgum	*Liquidambar styraciflua*
Sweet vernalgrass	*Anthoxanthum odoratum*
Switchgrass	*Panicum virgatum*
Sycamore	*Platanus occidentalis*
Tamarack	*Larix laricina*
Tartarian honeysuckle	*Japonica tartarica*
Tearthumb	*Polygonum sagittatum*
Thimbleberry	*Rubus parviflorus*
Thistle	*Cirsium* sp.
Timothy	*Phleum* sp.
Tobacco	*Nicothiana tabacum*
Toothed coast burnweed	*Erechtites minima*
Trailing blackberry	*Rubus ursinus*
Tropical cattail	*Typha domingensis*
Tulip-tree	*Liriodendron tulipifera*
Tupelo	*Nyssa* sp.
Tupelo gum	*Nyssa aquatica*
Umbrella-sedge	*Cyperus strigosus*
Velvet grass	*Holcus lanatus*
Vibirnum	*Vibirnum* sp.

List of Plants (Continued)

Common Name	Scientific Name
Water-hemlock	Cicuta curtissii
Waterlily	Family: Nymphaeaccae
Water milfoil	Myriophyllum spp.
Water oak	Quercus nigra
Water-pimpernel	Samolus parviflorus
Water-starwort	Callitriche spp.
Watson's willow herb	Epilobium watsonii
Wax-myrtle	Myrica californica
Western Hemlock	Tsuga heterophylla
Western Redcedar	Thuja plicata
Wheat	Triticum sp.
White ash	Fraxinus americana
White cedar	Chamaecyparis thyoides
White clover	Trifolium repens
White oak	Quercus alba
White pine	Pinus strobus
White spruce	Picea glauca
White sweet clover	Melilotus alba
Widgeongrass	Ruppia sp.
Wild carrot	Daucus carota
Wild celery	Vallisneria americana
Wild grape	Vitis sp.
Wild millet	Echinochloa spp.
Wild radish	Raphanus sativus

List of Plants (Continued)

Common Name	Scientific Name
Wild rice	Zizania aquatica
Willow	Salix spp.
Wintergreen	Gaultheria procumbens
Witch-hazel	Hamamelis virginiana
Yarrow	Achillea spp.
Yarrow	A. millefolium
Yellow sandverbena	Abronia latifolia
Yew	Taxus yew
Yucca	Yucca sp.

List of Invertebrates

American Oyster	*Crassostrea virginica*
Blue Crab	*Callinecthes sapidus*
Fiddler Crab	*Uca* spp.
Hard Clam	*Mercenaria mercenaria*
Marsh Grasshopper	*Orchelimum marginata*
Marsh Mussels	*Modiolus demissus*
Marsh Snail	*Melampus bidentatus*
Mud Crab	*Eurytium limosum*
Mud Fiddler Crab	*Uca pugnax*
Oyster	*Crassostrea virginica*
Red-jointed Fiddler Crab	*Uca minax*
Ribbed Mussels	*Modiolus demissus*
Salt Marsh Grasshopper	*Orchelimum marginata*
Salt Marsh Periwinkle	*Littorina irrorata*
Sea Cat	*Gallicthes felis*
Shrimp	*Peneus* spp.
White Shrimp	*Peneus setiferus*

List of Fish

Common Name	Scientific Name
Blowfish	*Lagocephalus* sp. and *Sphaeroides* sp.
Bluefish	*Pomatomus saltatrix*
Bluegill	*Lepomis macrochirus*
Bonito	*Sarda* sp.
Bowfin	Family: Amiidae
Bullhead	*Ictalurus* spp.
Carp	*Cyprinus carpio*
Channel Bass	*Sciaenops ocellatus*
Channel Catfish	*Ictalurus punctatus*
Croaker	Family: Scianidae
Eel	Family: Anguillidae
Flounder	Family: Bothidae
Flyingfish	Family: Exocoetidae
Goldfish	*Carassius auratus*
Herring	Family: Clupeidae
Hornpout	*Ictalorus nebulosus*
Largemouth Bass	*Micropterus salmoides*
Menhaden	*Brevoortia* spp.
Minnow	Family: Cyprinidas
Mullet	*Mugil* sp.
Northern Pike	*Esox tucius*
Perch	Family: Percidae

List of Fish (Continued)

Common Name	Scientific Name
Pickerel	*Esox lucius*
Pike	Family: Esocidae
Salmon	*Oncorhynchus* sp.
Sea Cat	*Galliethes felis*
Shad	*Alosa* sp.
Spot	*Leiostamus xanthurus*
Squiteaque	---?
Suckers	Family: Catostomidae
Sunfish	Family: Centrarchidae
Tarpon	*Megalops atlantica*
Tom Cod	Family: Microgadus
Trout	Family: Salmo
Whitefish	*Anarhichas lupus*

List of Reptiles

Common Name	Scientific Name
Bronze Frog	*Rana clamitans clamitans*
Bullfrog	*Rana catesbieana*
Chicken Turtle	*Dierochelys reticularia*
Cottonmouth	*Agkistrodon piscivorus*
Cricket Frog	*Acris* spp.
Diamond-backed Terrapin	*Malaclemys terrapin*
Green Frog	*Rana clamitans melanota*
Green Tree Frog	*Hyla cinerea*
Leopard Frog	*Rana pipiens*
Massasauga	*Sistrurus catenatus*
Mud Puppy	*Necturus maculosus*
Mud Turtle	*Kinosternon subrubrum*
Pig Frog	*Rana grylio*
Red-eared Turtle	*Pseudemys scripta elegans*
Snapping Turtle	*Chelydra serpentina*
Spring Peeper	*Hyla crucifer*
Water Snake	*Natrix* spp.
Woodland Salamander	*Plethodon* spp.
Yellow-bellied Turtle	*Pseudemys scripta scripta*

List of Birds

Common Name	Scientific Name
American Avocet	*Recurvirostra americana*
American Coot	*Fulica americana*
American Kestrel	*Falco sparverius*
American Knot	*Calidris canutus*
American Robin	*Turdis migratorius*
American Wigeon	*Anas americana*
American Woodcock	*Philohela minor*
Bachman's Sparrow	*Aimophila aestivalis*
Bald Eagle	*Halioeetus leucocephalus*
Belted Kingfisher	*Megaceryle alcyon*
Black-bellied Plover	*Pluvialis squatarola*
Black-crowned Night Heron	*Nycticorax nycticorax*
Black Duck	*Anas rubripes*
Black-necked Stilt	*Himantopus mexicanus*
Black Skimmer	*Rynchops nigra*
Blue Jay	*Cyanocitta cristata*
Blue-winged Teal	*Anas discors*
Boat-tailed Grackle	*Cassidix major*
Bobwhite	*Colinus virginianus*
Brown-headed Nuthatch	*Sitta pusilla*
Canada Goose	*Branta canadensis*
Cardinal	*Cardinalis cardinalis*
Carolina Chickadee	*Parus carolinensis*

List of Birds (Continued)

Common Name	Scientific Name
Caspian Tern	Hydroprogne caspia
Cattle Egret	Bubulcus ibis
Cedar Waxwing	Bombycilla cedrorum
Clapper Rail	Rallus longirostria
Common Gallinule	Gallinula choropus
Common Grackle	Quiscalus quiscala
Common Snipe	Capella gallinago
Common Tern	Sterna hirando
Cowbird	Molothrus ater
Dark-eyed Junco	Junco hyemalis
Dunlin	Calidris alpina
Eastern Bluebird	Sialia sialis
Eastern Goldfinch	Spinus tristis
Eastern Meadowlark	Sturnella neglecta
Eastern Phoebe	Sayornis phoebe
Evening Grosbeak	Hesperiphona vespertina
Forester's Tern	Sterna forsteri
Gadwall	Anas strepera
Geese	Family: Anatidae
Glossy Ibis	Family: Icteridae
Golden-crowned Kinglet	Regulus satrapa
Grackles	Plegadis falcinellus
Gray Catbird	Dumetella carolinensis

List of Birds (Continued)

Common Name	Scientific Name
Great Blue Heron	*Ardea herodias*
Great Crested Flycatcher	*Myiarchus crinitus*
Great Egret	*Casmerodius albus*
Greater Yellowlegs	*Tringa melanoleucus*
Green Heron	*Butorides virescens*
Green-winged Teal	*Anas crecca*
Gull-billed Tern	*Gelochelidon nilotica*
Hawks	Family: Accipitridae
Herring Gull	*Larus argentatus*
Hudsonian Godwit	*Limosa haemastica*
King Rail	*Rallus elegans*
Laughing Gull	*Larus atricilla*
Least Sandpiper	*Calidris minutilla*
Least Tern	*Sterna albifrons*
Lesser Scaup	*Aythya affinis*
Lesser Yellowlegs	*Tringa flavipes*
Little Blue Heron	*Florida caerulea*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Long-billed Marsh Wren	*Telmatodytes palustris*
Louisiana Heron	*Hydranassa tricolor*
Mallard	*Anas platyrhynchos*
Marsh Hawk	*Circus cyaneus*
Mockingbird	*Mimus polyglottos*

List of Birds (Continued)

Common Name	Scientific Name
Mourning Dove	Zenaida macroura
Mute Swan	Cygnus olor
Nuthatch	Family: Sittidae
Osprey	Pandion haliaetus
Palm Warbler	Dendroica palmarum
Pintail	Anas acuta
Pond Ducks	Family: Antidae
Purple Finch	Carpolacus purpureus
Purple Martin	Progne subis
Red-bellied Woodpecker	Centurus carolinus
Red-cockaded Woodpecker	Dendrocopos borealis
Red-tailed Hawk	Buteo jamaicensis
Red-winged Blackbird	Agelaius phoeniceus
Ring-billed Gull	Larus delawarensis
Ring-necked Pheasant	Phasianus colchicus
Roseate Tern	Sterna dougallii
Royal Tern	Thalasseus maximus
Ruby-crowned Kinglet	Regulus calendula
Ruffed Grouse	Bonasa umbellus
Sanderling	Calidris alba
Sandwich Tern	Thalasseus sandvicensis
Savannah Sparrow	Passerculus sandwichensis

List of Birds (Continued)

Common Name	Scientific Name
Semipalmated Plover	Charadrius hiaticula
Semipalmated Sandpiper	Calidris pusillus
Sharptailed Sparrow	Ammospiza caudacuta
Short-billed Dowitcher	Limnodromus griseus
Shoveler	Anas clypeata
Snowy Egret	Egretta thula
Solitary Sandpiper	Tringa solitaria
Song Sparrow	Melospiza melodia
Sparrows	Family: Ploceidae
Spotted Sandpiper	Actitis macularia
Starling	Sturnis vulgaris
Swallows	Family: Hirundinidae
Tree Sparrow	Spizella arborea
Tufted Titmouse	Parus bicolor
Turkey	Meleagris gallopavo
Turkey Vulture	Cathartes aura
Western Sandpiper	Calidris mauri
White Ibis	Eudocimus albus
Willet	Catoptrophorus semipalmatus
Woodcock	Philohela minor
Wood Duck	Aix sponsa
Wood Ibis	Mycteria americana
Yellow-crowned Night Heron	Nyctanassa violacea

List of Mammals

Common Name	Scientific Name
Beaver	*Castor canadensis*
Black Bear	*Ursus americanus*
Black-tailed Deer	*Odocoileus columbianus*
Brush Rabbit	*Sylvilagus bachmani*
Deer Mouse	*Peromyscus maniculatus*
Eastern Chipmunk	*Tamias striatus*
Eastern Cottontai'	*Sylvilagus floridanus*
Fox Squirrel	*Sciurus niger*
Gray Squirrel	*Sciurus carolinensis*
Ground Squirrel	*Citellus* spp.
Marsh Rabbit	*Sylvilagus palustris*
Mink	*Mustela vison*
Mole	Family: Talpidae
Muskrat	*Ondatra zibethica*
Norway Rat	*Rattus norvegicus*
Raccoon	*Procyon lotor*
Striped Skunk	*Mephitis mephitis*
Swamp Rabbit	*Sylvilagus aquaticus*
Vole	Family: Cricetidae
White-footed Mouse	*Peromyscus leucopus*
White-tailed Deer	*Odocoileus virginianus*
Woodchuck	*Marmota monax*

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Dames & Moore
Review of dredged material disposal techniques to identify wildlife habitat development factors / by Dames & Moore, San Francisco, Calif. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1977.
199, [100] p. : ill. ; 27 cm. (Miscellaneous paper - U. S. Army Engineer Waterways Experiment Station ; D-77-5)
Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract No. DACW39-74-C-0033 (DMRP Work Unit No. 5B04)
Literature cited: p. 184-194.

1. Disposal areas. 2. Dredged material disposal. 3. Succession. 4. Waste disposal sites. 5. Wildlife habitats. I. United States. Army. Corps of Engineers. II. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; D-77-5.
TA7.W34m no.D-77-5